ALBERTA'S STATE OF THE ENVIRONMENT COMPREHENSIVE REPORT

Alberta
ENVIRONMENTAL PROTECTION

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MESSAGE FROM THE MINISTER

I am pleased to present the 1994 Alberta State of the Environment Comprehensive Report. This document is the first state of the environment (SOE) report to be published in this province, and represents a significant development for the Department of Environmental Protection and our government. A starting point for SOE reporting in Alberta, the next comprehensive report will be produced in 1999. By comparing the data in that report with this current report, the reader will be able to understand trends in the condition of the environment. In the years between the comprehensive reports, shorter annual SOE reports will tackle, in detail, specific issues and themes.

As explained in the report, Alberta's high-quality resources are being managed for our continued enjoyment and use. Albertans depend on this sound and sustainable management to maintain our high-quality environment, which in turn supports our economic well-being and continued high quality of life.

Alberta's high environmental standards ensure that and our air, water and land-based resources are being protected and maintained at a high quality. With expanding human populations, the increasing demands for materials, energy and space, and the ever-present impact of natural forces, the stresses on our natural environment are increasing. These stresses, if unmanaged, may impair the life-supporting capability of our environment, both on a local and global scale. Management practices need to be continually reviewed to ensure they result in sustainable resource use and protection. In this respect, I believe that SOE reporting using environmental indicators is very important.

Partnerships and cooperation are crucial for the success of environmental reporting. The material for this SOE report was provided by staff from the provincial departments of Environmental Protection, Energy, Health, and Agriculture, Food and Rural Development. Assistance was also provided by Environment Canada. In the future, the development of SOE reports and fact sheets may involve more partners from the public sector as well as the private sector. Such partnerships are important; we must work cooperatively and share the responsibility for a healthy, sustained environment. I encourage you all to provide feedback on this and future SOE reports, so that together we can improve the quality of environmental reporting.

Ty Lund

Honourable Ty Lund,
Minister of Environmental Protection

MESSAGE FROM THE DEPUTY MINISTER

This report is a first for the Department of Environmental Protection, and the beginning of state of the environment reporting for Alberta. This first report is a further step towards a greater sharing of information on environmental issues, and a valuable tool that will be used in many ways, including as general information, an educational tool and a guide for environmental management decisions.

I would like to thank all the contributors who provided material for this report. The report collects a wide range of data and information, none of which could have been brought together without the help of many individuals from Alberta Environmental Protection as well as from Alberta Agriculture, Food and Rural Development, Alberta Energy and Alberta Health. The integration of information from these different department and agencies is an excellent example of the importance of cooperation.

The Department of Environmental Protection realizes how crucial partnerships and cooperation are for addressing environmental issues. As a recent example of cooperation related to the State of the Environment Report, the State of the Bow River Report, released in October, 1994, involved stakeholder groups including rural and urban municipalities, recreation, wildlife, fisheries, agriculture, irrigation, first nations peoples, parks, industry and citizens at large.

Our department is committed to integrating our efforts with those of other government departments and non-governmental organizations in working towards the wise management of our environment. Our first State of the Environment Report is an important part of these efforts, and I hope you find it interesting and informative.

Peter G. Melnychuk
Deputy Minister,
Environmental Protection

ACKNOWLEDGEMENTS

This report could not have been prepared without the help of many individuals across the provincial government. Contributions, advice and guidance for the report were provided by representatives from:

Alberta Environmental Protection

- Environment and Regulatory Services
- Fish and Wildlife Services
- Land and Forest Services
- Finance, Land Information and Program Support Services
- Parks Services
- Research and Strategic Services
- Water Resources Services
- Community Relations Division
- Human Resources Division

Alberta Agriculture, Food and Rural Development
Alberta Energy
Alberta Health

Many individuals from the departments listed above provided comments and feedback on drafts of this report. All of the comments were valuable in providing direction for the report. Invaluable advice and assistance were also provided by staff from Environment Canada.

SUMMARY OF KEY POINTS

AIR QUALITY

- There is a downward trend in carbon monoxide levels at many Alberta air quality monitoring stations. This trend is due to improvements in automobile engines.
- Levels of suspended particulates have decreased at all urban monitoring stations, due to less road dust and improvements in automobile engines.
- The levels of lead have decreased at all monitoring stations, mainly because of the banning of leaded gasoline.
- Ground-level ozone concentrations are generally lower in Alberta cities because this pollutant is destroyed by nitric oxide from automobile emissions.
- Levels of nitrogen dioxide show little change from the historic average.
- There is no discernible trend in the atmospheric concentrations of sulphur dioxide.
- There has been a long-term increase in precipitation acidity in Alberta. This could be the result of improved sampling techniques, or a change in the location of the monitoring sites.
- Transportation is a major source of carbon monoxide.
- Industrial plants are contributing emissions to the atmosphere. The major contributors are:
  -carbon monoxide through electricity generation, oil and gas production;
  -suspended particulates through electricity generation;
  -Volatile Organic Compounds (VOCs) through chemical plants;
  -oxides of nitrogen through oil and gas production, oil refining, electricity generation;
  -sulphur dioxide through oil and gas production, electricity generation; and
  -carbon dioxide through electricity generation, natural gas and petroleum use, fossil fuel production.
- Estimates of methane emissions vary widely. Coal production and burning, well blowouts and fuel combustion, as well as cattle, sheep, pigs, horses and wild grazing animals, all contribute to annual methane emissions.

WATER QUALITY AND QUANTITY

- Of the water that leaves Alberta through rivers, just under one-half originates within the province.
- Water flow in Alberta rivers varies from year to year. The Peace and Athabasca rivers show the least amount of variability and the Battle and Beaver rivers the greatest.
- Water quality varies with season, year and location. Water quality concerns in Alberta include the effects of discharges from the pulp industry and from urban areas, and levels of disease-causing bacteria, viruses and parasites.
- Variations in lake water quality occur around the province. This variation is a result of differences in soils, climate, vegetation, size of the drainage basin and groundwater entering the lake.
- Groundwater is a source of potable water, containing an estimated 100 million cubic decametres in sand and gravel aquifers alone.
- Southern Alberta has the greatest demand for water, but has only 14 percent of the water supply. Northern Alberta has most of the water supply, but the least demand.
- To meet water use demands, water is withdrawn from Alberta rivers, lakes and groundwater. In 1993, 6 822 382 cubic decametres of water were licensed for withdrawal. Most of the licensed water comes from the Bow, Oldman and North Saskatchewan rivers.
- Growing demands have caused shortages and full allocations of water from some river basins.
- Pulp mills discharge substances like suspended sediments and chlorinated organic compounds (e.g., dioxin). Most (about 99 percent) of the chlorinated organics pose little or no environmental threat. Since 1991, there have been no detectable levels of dioxin in water samples collected by the four Alberta kraft pulp mills.
- Pesticides have been detected in all Alberta river basins. In most cases, the significance of detecting them is not known. Most pesticides have only been detected in only a small number

of samples. Lindane, alpha BHC, 2,4-D and 2,4,5-T are the pesticides that are most frequently detected.

- There are 92 major water management projects in Alberta.

- Water must be treated to remove contaminants. The number of people supplied with treated water in Alberta has increased compared with the number of those who are not.

FORESTRY

- According to the Phase 3 forest inventory (the most extensive inventory to date), 53 percent of the forested land in Alberta is productive, 6 percent is potentially productive and 37 percent is non-productive. The three most numerous tree species are white spruce, aspen and pine.

- Fire is a significant threat to forests in Alberta, resulting in an average annual loss of about 22 000 hectares over the past 10 years. Alberta's Wildfire Suppression Program has, however, helped to reduce these losses.

- A number of insect pests and diseases threaten forested lands in the province. Eastern spruce budworm has had the most significant impact. A study is currently investigating the effectiveness of a bacterial agent for controlling this pest.

- Timber harvesting is a major disturbance to forest ecosystems. To mitigate the impacts of this activity, Alberta forests are managed on a sustained yield basis, which sets yearly levels of permitted timber harvest (the annual allowable cut, or AAC). From 1991 to 1992, 68 percent of the coniferous AAC and 22 percent of the deciduous AAC was harvested.

- Other activities that stress the forests in Alberta include agriculture, oil and gas exploration and recreational activities.

- There are ground rules in Alberta that outline how timber is to be harvested from public land. Timber companies prepare plans, which are reviewed by government to ensure that the ground rules are followed.

- Reforestation is an important part of the sustained yield management of Alberta's forests. Of those areas harvested before 1991, the majority (97 percent) have been satisfactorily restocked (the percentage of the area meeting the reforestation standard of the total area expected to meet the standard in that year).

- The Alberta Forest Conservation Strategy is currently being developed by participants from the forest industry and the environmental, aboriginal, Metis and academic communities. The Alberta Government is serving as an advisor and facilitator. The goal of the strategy is wise, long-term management of our forest ecosystems.

AGRICULTURE

- Agricultural land covers about 21 million hectares or one-third of the provincial land base.

- Approximately 4 percent of the cultivated landbase is under irrigation; irrigation farms generate 16 percent of the province's agricultural production.

- Nearly all of Alberta's arable land is now under cultivation and opportunities for expansion are minimal.

- More than 600 000 hectares of farmland are at risk of water erosion each year.

- Salinity occurs on an estimated 647 000 hectares of dryland, reducing crop yield by an average of 25 percent.

- Of 650 000 hectares of surveyed land in the irrigated part of the province, 12.4 percent were affected by salinity related to irrigation and 13.5 percent were affected by dryland salinity.

- Data from 1991 show that 83 percent of the farms reporting used conventional tillage, 21 percent used conservation tillage and 5 percent used no-till.

- Since 1989, more than 144 000 hectares of environmentally sensitive farmland in Alberta was returned to permanent cover of grass or trees.

- There are more than 400 000 hectares of strongly acid and 1.8 million hectares of moderately acid soils farmed in Alberta.

MINERAL RESOURCES

- Almost three-quarters of the energy produced in Canada comes from Alberta.
- There are about 150 000 active and inactive oil and gas wells in Alberta, each covering approximately 1 hectare of land.
- Oil sands activity and coal mining affect over 30 000 hectares of land to date, of which over 9000 hectares have been reclaimed.
- Sand and gravel removal also stresses the land resource. In 1993, approximately 420 000 cubic metres of material was removed from public land alone.
- The construction of pipelines results in disturbance to the land surface and to wildlife. From 1987 to 1993, there was approximately 1.4 million square metres of pipeline constructed each year.
- In 1993, the Energy Resources Conservation Board coordinated the abandonment of 25 orphan wells.
- New mineral extraction technology, such as horizontal and directional drilling, is reducing the environmental impacts of oil and gas development.

WETLANDS

- Wetlands cover approximately 13.7 million hectares of Alberta, or about 20 percent of the province's land base.
- 90 percent of the 1.1 million marshlands in the White Area are less than 2 hectares in area.
- From 1970 to 1990, there was a 30 percent reduction in the number of marshlands, due primarily to wetland drainage and secondarily to the dry climate of the 1980s.
- About $45 million has been spent in Alberta on wildlife habitat activities through the North American Waterfowl Management Plan.

PROTECTED AREAS

- National Parks, National Wildlife Areas, Wilderness Areas, Wilderness Parks, Ecological Reserves, Provincial Parks and Natural Areas are classifications of protected areas. These types of protected areas differ in their purpose and level of protection.
- Currently, more than 9 percent of Alberta is under protected area status.
- The most significant periods of protected areas development in Alberta occurred before 1930 when 87 percent of the currently protected area was designated, and between 1950 and 1960 with the designation of Willmore Wilderness Park.
- In Alberta, 47 protected areas exceed the International Union for the Conservation of Nature's criterion of 1000 hectares as the minimum size of a protected area.
- In total, approximately 48 percent of all Level 1 targets are protected within the existing legislated protected areas.
- Protected areas legislation in Alberta allows for different types and levels of development to occur in protected areas.
- Land disturbance over the past 100 or so years also affects the amount of land remaining in a natural state that could be used to select new protected areas. Preliminary estimates indicate that human activities have disturbed:
  - more than 80 percent of the native prairies;
  - more than 60 percent of the prairie's wetlands;
  - about 90 percent of the fescue prairie;
  - approximately 76 percent of the mixed prairie; and
  - about 75 percent of the aspen parkland.
- Portions of two Alberta rivers have been designated as protected under the Canadian Heritage Rivers System Program.

WASTE MANAGEMENT

- Landfilling is the most common method of disposal for municipal solid waste. Currently in Alberta, there are about 340 approved municipal landfills.

- Since 1976, over 220 smaller waste disposal sites have been replaced with 28 regional waste management systems. This restructuring has helped reduce complaints and concerns about pollution from waste management. There are several new regional landfill systems either in development or under consideration.

- Special wastes are collected by the Alberta Special Waste Management Corporation and treated by the Alberta Special Waste Treatment Centre. The latter facility has, to the end of 1993, treated over 43 500 tonnes of waste.

- The waste disposal rate in Alberta has dropped from 1.15 tonnes per capita in 1988 to 0.98 tonnes in 1992. This reduction is mainly a result of successful efforts to minimize waste.

- Recycling programs are becoming increasingly popular. Currently, over 100 municipal facilities in Alberta collect recyclable materials.

- In 1993, over 500 million beverage containers were returned to depots.

- The Tire Recycling Management Board is currently developing strategies to deal with the 2.4 million scrap tires generated annually in Alberta.

- The Alberta Used Oil Recycling Pilot Project is looking at the effectiveness of depots that collect waste oil.

- Consumer dry cell batteries are not being recycled. Automotive SLI batteries, however, have a 75 to 80 percent recycling rate.

- About 75 percent of used pesticide containers are being returned to collection sites and recycled.

- Presently, used chlorofluorocarbons are being captured and contained for recycling, since there is no method of disposal.

- New drilling waste management and disposal requirements have been developed by the Energy Resources Conservation Board. These requirements will ensure that all drilling waste is analysed to determine an appropriate disposal option.

BIOTA

- About a quarter of Alberta's native plant species are considered rare. Some are threatened or endangered, but there is insufficient information to designate plants appropriately.

- Ninety-five percent of Alberta's populations of mammals, birds, fish, reptiles and amphibians are considered sustainable. Twenty-two species are at serious risk.

- Proportionally, more Albertans participate in wildlife-related activities than in any other province in Canada.

- Because hunting and fishing have significant impacts on the wildlife resource, these activities are carefully managed.

- Fish stocking maintains some natural fish populations in Alberta and provides fish for sportfishing.

- The Alberta Fish and Wildlife Trust Fund continues to fund a significant number of programs that protect wildlife species and their habitats.

- There are some national and provincial programs that aim to protect and, in some cases, reintroduce endangered wildlife species.

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1.0 INTRODUCTION

What is state of the environment reporting? What is its purpose? State of the environment reports are produced by many jurisdictions across Canada and in other countries. Their purpose is to provide information to readers about the condition of the environment. Patterns of change in the quality of the environment are illustrated along with efforts to improve or maintain environmental quality.

Through regular reporting, changes in environmental conditions over time can be evaluated and corrective actions taken. With increased understanding of the trends occurring in the environment and the use of resources, society can make more informed decisions and more responsible choices — ones which are environmentally sustainable over the long term.

Organization of the Report

This document is Alberta's first State of the Environment (SOE) Report for Alberta. This report is comprehensive, in that it looks at all aspects of the environment—air, water, land and wildlife. It will give the reader a broad, overall picture of the state of the province's environment.

The first section of this report sets the stage by briefly describing the population, economy and natural regions of Alberta. The remainder of the report is divided into major sections covering air, water, land and biota. Each of these major sections uses a selection of data and information to describe the following:

- the present conditions of the environment given human and natural activities;
- the impact that human and natural activities have on the environment — impacts that, when managed properly, result in the sustained use of resources; and
- actions or management responses that strive to protect, enhance and restore the environment so that sustainable use is possible.

This report also includes a glossary that readers could consult if a term in this report is unfamiliar.

Indicators

Wherever possible, the report presents information by way of environmental indicators. These are measurements of different aspects of the environment; they are used to monitor, describe and interpret changes in the environment. To understand what an indicator is, consider gross domestic product (GDP), which is used as an indicator of the economic prosperity of Canada.

It is important to note that environmental indicators represent very complex ecological systems. The cause and effect relationships between indicators and environmental quality are still being studied. Work continues provincially, nationally and internationally on developing and understanding these indicators.

Scope of the Report

Alberta's first SOE report provides the reader with the most up-to-date information available on the state of our environment. Some data in this report are more recent than others and the time period over which data have been collected varies. This is because data have been collected by different agencies for different purposes, few of them connected with SOE reporting specifically. Future reports will build on this report, further improve and refine indicators and provide a more complete picture of our ability to manage and protect our environment.

Indicators in this report are based on available data. However, for some important environmental components, indicators do not exist and therefore could not be presented in this report. Indicator development is ongoing, and the number and quality of indicators for Alberta are expected to improve.

To acknowledge the interconnected nature of environmental issues, it would be desirable to report data on an ecosystem basis. Currently, such reporting is not possible, since most data are collected regionally or provincially. Alberta government agencies are, however, moving toward a new style of resource management—ecosystem management—which looks at natural resources on an ecosystem or natural region basis.

2.0 SETTING THE STAGE

This section provides some general context for the reader, by giving a thumbnail sketch of Alberta's population, economy, land base and natural regions. Also discussed are the relationships between environmental and human health.

Alberta's Population

As of 1991, a total of 2 545 553 people resided in Alberta (Table 2.1). From 1981 to 1991, the population increased by 13.8 percent. In 1991, the population density was 4.0 people per km^2. More than 65 percent of the people in Alberta live in one of its 15 cities (Table 2.2). The two largest cities are Calgary, with 27.9 percent of the population, and Edmonton, the province's capital, with 24.2 percent of the total provincial population.

Table 2.1 Population Growth in Alberta, 1971, 1981 and 1991.

	1971	1981	1991
population	1 627 875	2 237 725	2 545 550
% national population	7.5	9.2	9.3
% Change (71-81, 81-91)	--	37.5	13.8

Source: Environment Council of Alberta, 1994.

Table 2.2 Urban and Rural Population Breakdown, 1990.

Population	1971*	1991**
Urban:	1 196 250 (73.5%)	2 030 893 (80%)
Rural:	514 660 (26.5%)	514 660 (20%)
Total:	1 627 875	2 545

* Source: Statistics Canada, 1977.
** Source: Statistics Canada, 1992.

Alberta's Economy

Alberta has some of the richest oil and gas producing areas in Canada. About half of the value of all minerals produced in the country comes from Alberta. Between 80 and 85 percent of oil and gas consumed in Canada is produced in Alberta. Grain production and livestock production are also important. Chemicals, chemical products and food are the top three commodities that a diversified manufacturing sector produces.

In 1992, 36.4 percent of employed people in Alberta worked in community, business and personal services sectors. The second highest proportion worked in the retail and wholesale trade sector, with 17.4 percent. The transportation, storage and communication sector and the agriculture industry followed with 7.5 and 7.2 percent, respectively (Table 2.3). Alberta's petroleum, gas and mining sectors, which employed about 68 000 people as of 1992, are other major components of the provincial economy.

Table 2.3 Employment by Industry, 1992.

Industry	Number of people (000)	Percent Employed
• community, business and personal services	451	36.4
• retail and wholesale trade	216	17.4
• transportation, storage and communication	94	7.5
• agriculture	89	7.2
• construction	82	6.6
• public administration	80	6.5
• manufacturing	79	6.4
• finance, insurance and real estate	64	5.2
• petroleum, gas and related services	60	4.8
• forestry and related services	17	1.4
• mining and quarries (including coal)	8	0.6
• fishing and trapping	data not available	

Source: Environment Council of Alberta, 1994.

Alberta's Land Base

Land in Alberta receives different administrative classifications. Private land, public land (owned and managed by the Government of Alberta) and federally controlled land (owned and managed by the Government of Canada) are the broadest subdivisions. A detailed breakdown of the status of Alberta land is provided in Table 2.4.

In Alberta the provincial government owns the mineral rights under most of the land. Consequently, government establishes the terms under which mineral rights are licensed or leased to potential users. The fact that the provincial government is the primary owner of mineral rights in the province helps to ensure that sustainable development can occur. The province has an economic and environmental interest in ensuring that mineral resources are used for the benefit of current and future generations of Albertans.

Alberta's Natural Regions

Alberta spans a broad area of about 66 million hectares and contains a diversity of natural features. Elevations range from 3700 metres above sea level along the continental divide, to lower than 300 metres in the northeastern corner of the province. Geologic events have produced a wide variety of terrain throughout the province. Climatic variation produces climates typical of the prairies, mountains and boreal forest that occur in Alberta.

Table 2.4 Status of Land in Alberta (as of March 31, 1994).

	Area (Hectares)	Percentage of Alberta
Privately Owned Land	18 643 500	28.2
Public Land		
· Under Disposition Leading to Title	172 800	0.3
· Under Disposition Not Leading to Title	2 923 300	4.4
· Special Areas*	1 152 500	1.7
· Protected Areas and Recreation Areas	831 200	3.1
· Metis Settlements	512 000	0.8
· Forested Land Within the Green Area**	19 805 600	30.0
· Forest Management Agreement Areas	13 315 400	20.1
· Vacant Public Land Within the White Area***	1 730 900	2.6
Indian Reserves	667 700	1.0
Federally Controlled Land (National Parks, Research Stations, Department of National Defence Land, etc.)	6 363 600	9.6
Total Area of Alberta	**66 118 500**	**100.0**
Land	**64 438 900**	**97.5**
Water	**1 679 600**	**2.5**

*Special Areas are a unique classification of public land under the jurisdiction of Alberta Municipal Affairs. This number includes some tax recovery land.

**Green Area: Forested land withdrawn from settlement and managed for forestry and other multiple uses.

***White Area: The settled area of the province, managed for multiple use pursuant to the *Public Lands Act* and Regulations.

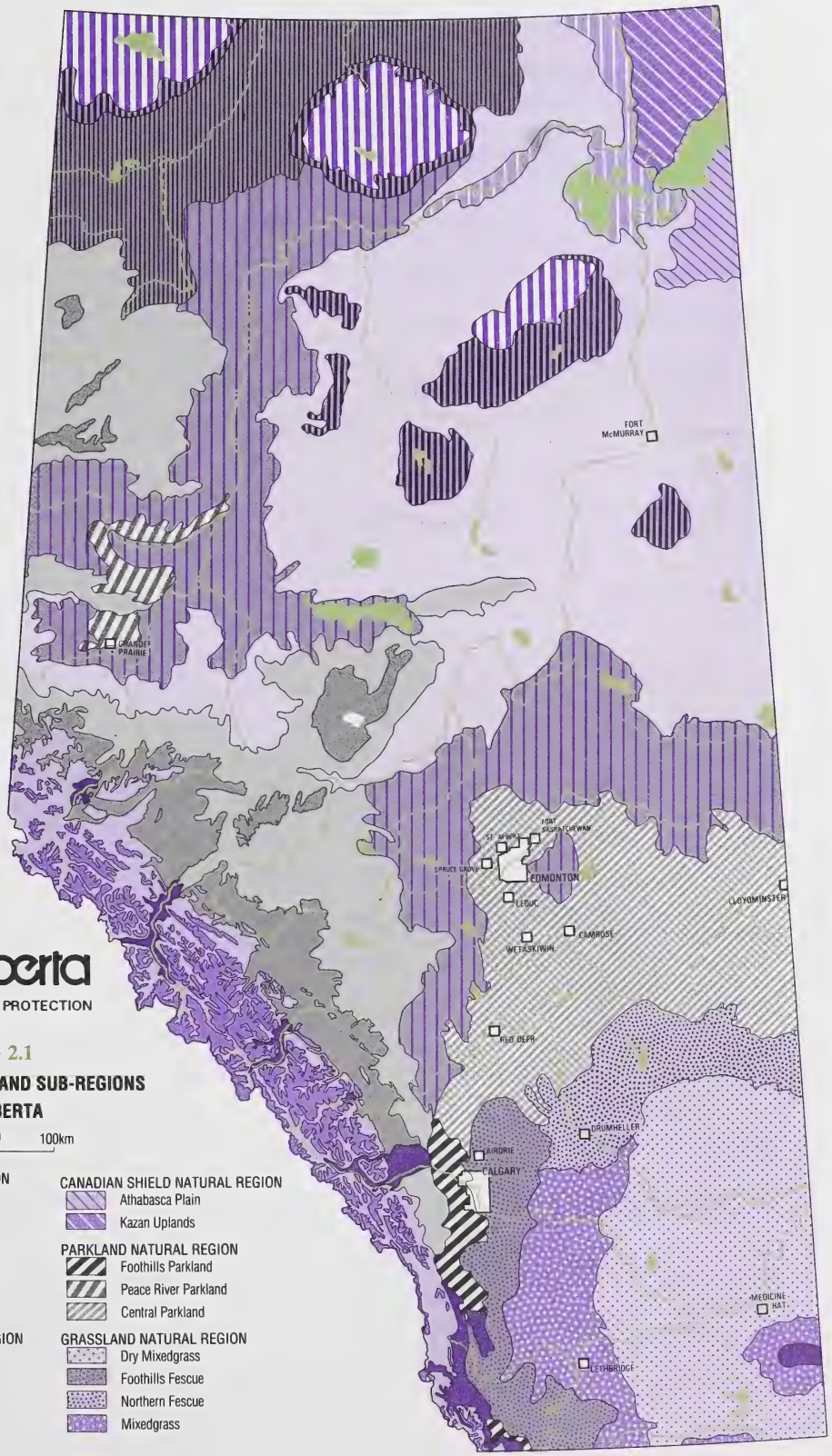
Source: Land and Forest Services, Alberta Environmental Protection.

The interaction of terrain and climatic variation has led to a rich diversity of landscapes across the province. A new classification system describes Alberta's natural landscapes through similarities in landforms, water, geology, soils, climate, plants and wildlife (Figure 2.1 and Table 2.5). The largest units are termed natural regions, of which there are six in Alberta. Each natural region is subdivided into two or more natural subregions, of which there are 20 in total. These natural regions are described in more detail in Appendix 1.

The Environment and Human Health

The health of the environment and human health are closely linked. The environment, personal lifestyle and our genetic make-up all play a role in determining our overall health. Human activities over the past decades have altered our chemical, physical and biological environment and have increased the chances of exposure to environmental contaminants. Worldwide environmental changes, such as the depletion of the ozone layer and global warming, could also affect the health of populations.

At present there are insufficient data to accurately determine the effects of many environmental contaminants on human health. Such determination depends on knowing the level of exposure a person receives. Unfortunately, there is usually little information on the actual exposure of individuals to contaminants. In addition, it is not clear to what extent contaminant exposure influences the occurrence of diseases. Studies are needed to fill in gaps and show a more complete picture. Some projects have recently been approved by the provincial government to help fill those gaps.



Alberta

ENVIRONMENTAL PROTECTION

Figure 2.1

NATURAL REGIONS AND SUB-REGIONS OF ALBERTA

0 50 100km

BOREAL FOREST NATURAL REGION
- Central Mixedwood
- Dry Mixedwood
- Wetland Mixedwood
- Sub-Arctic
- Peace River Lowlands
- Boreal Highlands

ROCKY MOUNTAIN NATURAL REGION
- Alpine
- Sub-Alpine
- Montane

FOOTHILLS NATURAL REGION
- Upper Foothills
- Lower Foothills

CANADIAN SHIELD NATURAL REGION
- Athabasca Plain
- Kazan Uplands

PARKLAND NATURAL REGION
- Foothills Parkland
- Peace River Parkland
- Central Parkland

GRASSLAND NATURAL REGION
- Dry Mixedgrass
- Foothills Fescue
- Northern Fescue
- Mixedgrass

Table 2.5 Summary of Alberta's Natural Regions and Subregions.

BOREAL FOREST NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
1. Central Mixedwood	Aspen forests	Gray Luvisols	Boreal
2. Dry Mixedwood	Aspen forests	Gray Luvisols	Boreal
3. Wetland Mixedwood	Aspen and black spruce forests, wetlands	Gray Luvisols, Gleysols, Organic soils	Boreal
4. Sub-Arctic	Black spruce forests	Gleysols, Cryosols, Organic soils	Boreal-Subarctic
5. Peace River Lowlands	Aspen-balsam poplar-white spruce forests and wetlands	Gray Luvisols, Gleysols, Regosols, Organic soils	Boreal
6. Boreal Highlands	Aspen-balsam poplar-white spruce forests and wetlands	Gray Luvisols, Gleysols, Organic soils	Boreal

ROCKY MOUNTAIN NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
7. Alpine	Alpine heath	Brunisols, Regosols	Cordilleran
8. Sub-Alpine	Lodgepole pine (Engelmann spruce-subalpine fir)	Eutric Brunisols	Cordilleran
9. Montane	Open Douglas-fir and pine forests, grasslands	Eutric Brunisols	Cordilleran-Prairie

FOOTHILLS NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
10. Upper Foothills	White and black spruce, lodgepole pine, subalpine fir forests	Gray Luvisols, Brunisols	Boreal-Cordilleran
11. Lower Foothills	Aspen-balsam poplar-white spruce, birch, black spruce forests	Gray Luvisols	Boreal-Cordilleran

Table 2.5 (continued).

CANADIAN SHIELD NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
12. Athabasca Plain	Jack pine forests and peatlands	Brunisols, Regosols	Boreal
13. Kazan Upland	Jack pine forests and black spruce peatlands	Brunisols, Organic soils, rock	Boreal

PARKLAND NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
14. Foothills Parkland	Aspen forests, fescue grasslands, willow grovelands	Brunisols, Regosols	Prairie-Cordilleran
15. Peace River Parkland	Aspen forests, grasslands	Eutric Brunisols	Boreal
16. Central Parkland	Aspen and balsam poplar forests, fescue grasslands	Orthic Black and Dark Gray Chernozems, Dark Gray Luvisols, Gleysols	Prairie-Boreal

GRASSLAND NATURAL REGION

Subregion	Typical Vegetation	Typical Soils	Dominant Climate
17. Dry Mixedgrass	Needle-grama grass	Brown Chernozems	Prairie
18. Foothills Fescue	Fescue-oat grass	Black Chernozems	Prairie
19. Northern Fescue	Rough fescue	Dark Brown Chernozems	Prairie
20. Mixedgrass	Needle-wheat grass	Dark Brown Chernozems	Prairie

Source: Parks Services, Alberta Environmental Protection.

3.0 ATMOSPHERE

The province's air quality is of great interest to Albertans. Air quality and its effects on the environment have received a great deal of attention over the past decade. Emissions released into the atmosphere can adversely impact ecosystem, human and animal health. Some important air quality issues in Alberta are:

- urban air quality;
- acid precipitation; and
- global warming.

Urban air quality is mainly affected by vehicle exhaust emissions and traffic movement. Air pollutants such as carbon monoxide and particulate matter, are released directly from vehicular exhaust. Smog, a light brown discoloration of the lower atmosphere, is often seen in major cities. Smog is made up of nitrogen dioxide, hydrocarbons, ozone and other compounds, and can result in reduced visibility and health concerns.

Acid precipitation is an environmental issue that is both local and regional in scale. Most acid precipitation is caused by emissions of sulphur oxides and oxides of nitrogen. These chemicals react with water in the atmosphere and are converted to sulphuric and nitric acid, respectively. Diluted forms of these acids eventually fall to the ground as precipitation.

Global warming is at the forefront of national and international environmental issues. Increasing concentrations of gases such as carbon dioxide and methane may eventually enhance the natural greenhouse effect of the earth's atmosphere. This enhanced greenhouse effect can potentially increase the surface temperature of the earth.

A. PRESENT CONDITIONS

Given the potential impacts, a number of air quality parameters are continually monitored in the province. Data collected by these monitoring activities provide information that can be used to address local, regional and global air quality issues. Data on air quality in this section comes from a monitoring network operated by the Government of Alberta. This monitoring network includes 9 continuous and 8 intermittent stations (Figure 3.1), over 250 static stations and 12 precipitation quality stations. Air parameters such as carbon monoxide, oxides of nitrogen, sulphur dioxide, precipitation quality and carbon dioxide are monitored.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles. Minor sources include fireplaces, industry, aircraft and natural gas combustion.

Based on annual average concentrations, a downward trend in carbon monoxide is evident at the Edmonton central and northwest stations, all Calgary stations and the Fort McMurray station (Figures 3.2A, B and C). Lower carbon monoxide concentrations at these stations can be attributed to more efficient automobile engines and emission control devices.

Suspended Particulate Matter

Air pollutants are not necessarily in gaseous form. Tiny particles of solid material or liquid aerosols, called particulates, are also present in the air and may constitute a pollution problem. Suspended particulate matter originates from soil, road and agricultural dust, smoke from forest fires and agricultural fires, vehicular exhaust emission and industrial emissions.

Particulates can affect human health. The particles enter the body through the respiratory system where most of their immediate effects are felt. Larger particles tend to deposit in the nose and throat, while smaller particles travel deeper into the lungs where it is harder for the body to remove them. The degree to which these particles are harmful depends on their chemical composition.

There have been significant decreases in suspended particulates at most urban monitoring stations in Alberta. This trend is most obvious in downtown and industrial areas of Edmonton and Calgary (Figure 3.3A, B). The downward trend in suspended particulates is mainly due to less road dust (because of more paved roads) and more efficient automobile engines.

Lead

Lead is emitted into the atmosphere primarily as a result of burning leaded gasoline in motor vehicles.

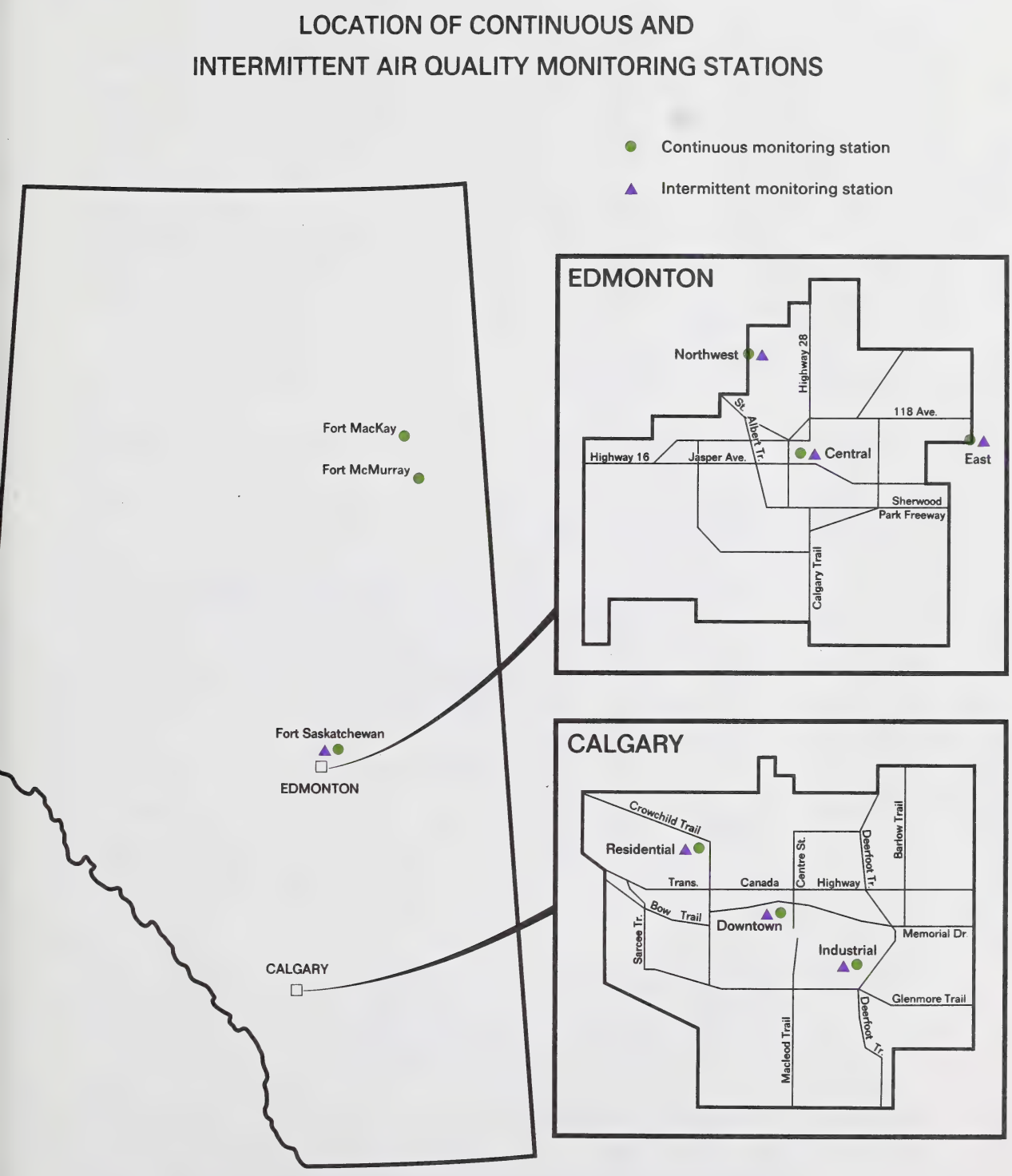


Figure 3.1 Location of Continuous and Intermittent Air Quality Monitoring Stations.

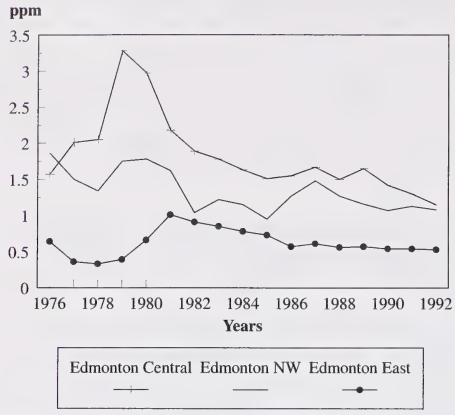


Figure 3.2A Average Annual Carbon Monoxide Concentrations - Edmonton.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

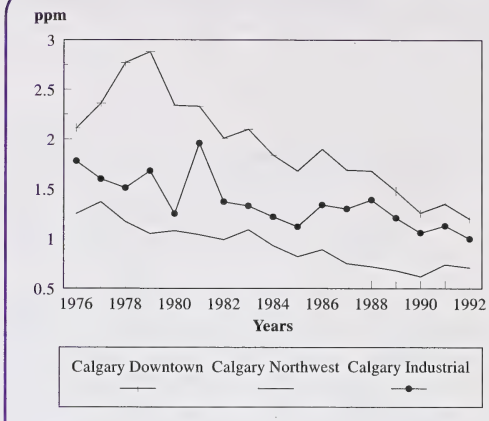


Figure 3.2B Average Annual Carbon Monoxide Concentrations - Calgary.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

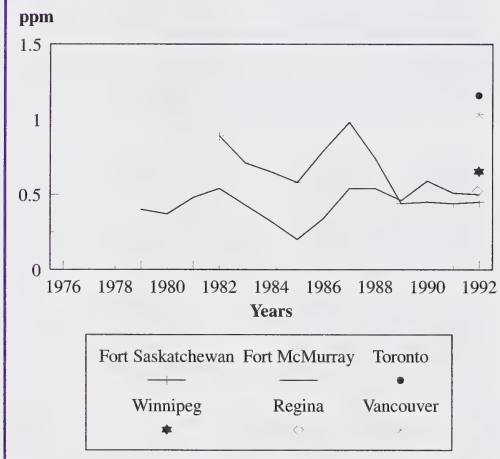


Figure 3.2C Average Annual Carbon Monoxide Concentrations - Northern Alberta and Selected Canadian Cities.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

Other minor sources of atmospheric lead include iron and steel manufacturing, solid waste incineration and battery manufacturing.

A decrease in annual average lead concentration is evident at all monitoring stations in Alberta (Figures 3.4A, B). (There are insufficient data for northern Alberta cities to constitute a trend; therefore, these data are not shown). This trend is most pronounced at the downtown locations in Edmonton and Calgary. The cause of lower lead loadings over the past 13 years is the decrease in the use of leaded gasoline. Lead in gasoline was eliminated in 1990.

Ground-Level Ozone

Ground-level ozone is a major component of photochemical smog. At normal outdoor concentrations, ozone is a colourless, odourless gas. However, ozone does have a characteristic sharp odour when at higher concentrations, such as during lightning storms.

Unlike many other pollutants, ozone is not emitted directly by human activities, but is generated by a chemical reaction between ultraviolet light from the sun, oxides of nitrogen and volatile organic compounds (VOCs). Some ozone is transported downward from the stratosphere to the ground.

On average, ozone concentrations in Alberta cities are lower than at rural locations (Figures 3.5A, B and C). This difference is due to the destruction of ozone by nitric oxide emitted by automobiles. An exception to this reaction occurs on warm, sunny days when ozone precursors produced by human

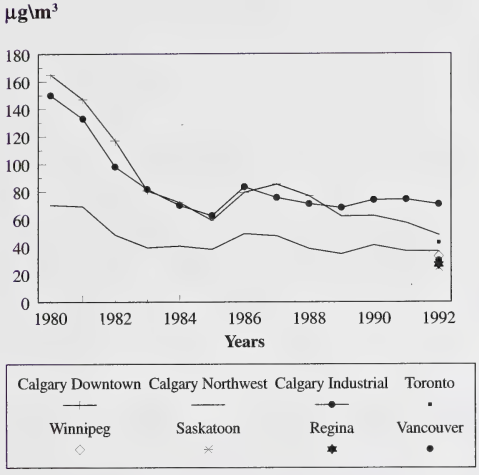


Figure 3.3A Average Annual Particulate Concentrations - Calgary and Selected Canadian Cities.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

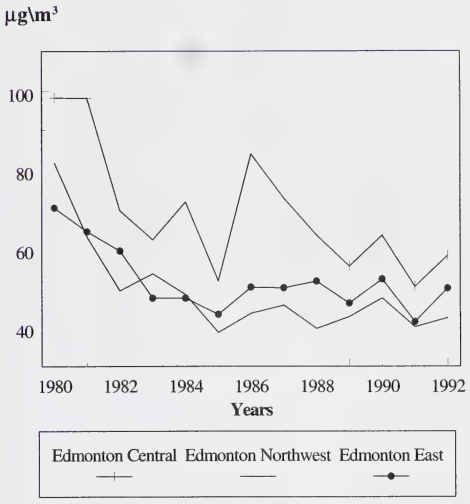


Figure 3.3B Average Annual Particulate Concentrations - Edmonton.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

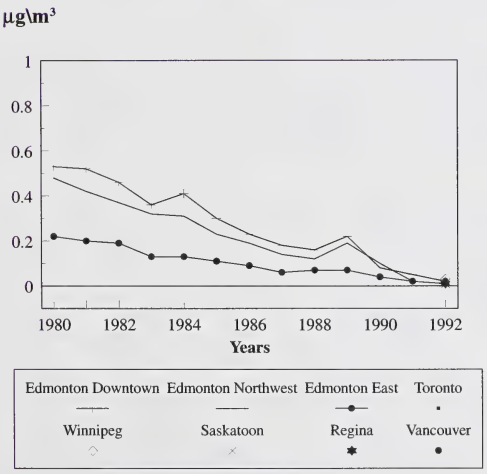


Figure 3.4A Average Annual Lead Concentrations - Edmonton and Selected Canadian Cities.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

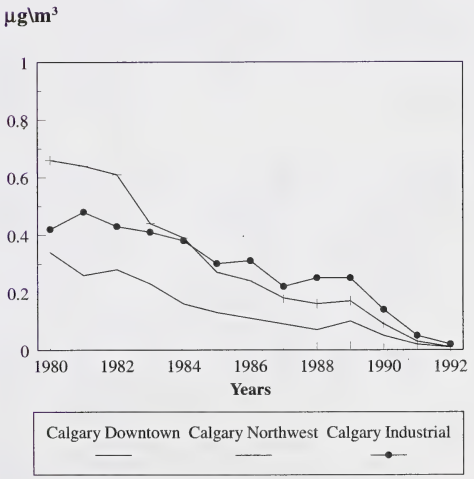


Figure 3.4B Average Annual Lead Concentrations - Calgary.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

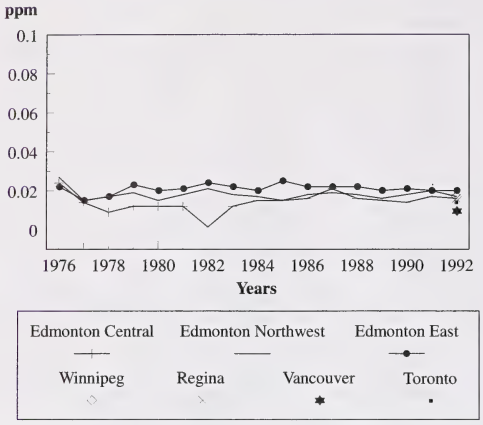


Figure 3.5A Average Annual Ozone Concentrations - Edmonton and Selected Canadian Cities.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

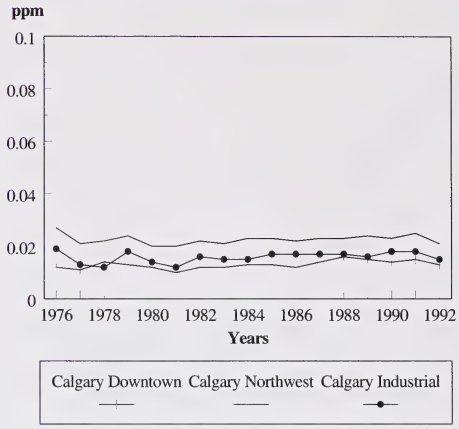


Figure 3.5B Average Annual Ozone Concentrations - Calgary.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

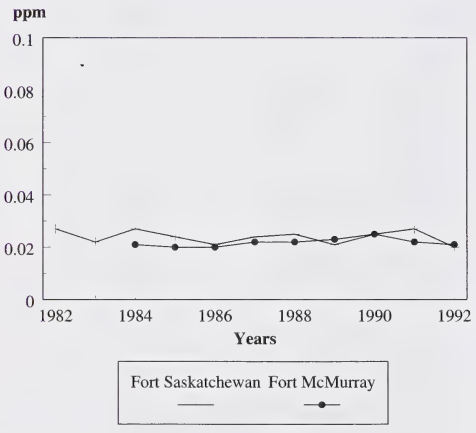


Figure 3.5C Average Annual Ozone Concentrations - Northern Alberta.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

activities lead to higher urban ground-level ozone concentrations.

Nitrogen Dioxide

Nitrogen dioxide is a reddish brown gas with a pungent odour, which is partially responsible for the brownish colour of the lower atmosphere in urban areas. Nitrogen dioxide is also a major contributor to acid precipitation.

Leading sources of nitrogen oxides include motor vehicle emissions (the largest source in urban areas), the oil and gas processing industry and power plants. Smaller sources of nitrogen oxides include heating fuel combustion, forest fires, fertilizer plants and aircraft emissions.

Based on 17 years of data, nitrogen dioxide shows a significant downward trend at the Edmonton central monitoring station (Figures 3.6A, B and C). Lower concentrations in downtown Edmonton may be due to decreased emissions of oxides of nitrogen from motor vehicles. The downward trend is evident from 1976 to 1984, after which there is a levelling off of concentrations. At other monitoring stations, nitrogen dioxide levels do not show significant

changes in the trend. For 1992, nitrogen dioxide levels were close to the same, or lower than the long-term average at most monitoring stations.

Sulphur Dioxide

Sulphur dioxide is a colourless gas with a pungent odour. It is the primary component of acid rain (see the following section on Precipitation Acidity). In Alberta, the major sources of sulphur dioxide are sour gas plants, oil sands and coal-fired electrical power plants. Other sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

Annual average concentrations of sulphur dioxide are not high enough to determine a significant trend. As a result, no figures are provided. Elevated sulphur dioxide values are occasionally reported at Fort MacKay and Fort McMurray monitoring stations. These elevated values are due to oilsands facilities located north of Fort McMurray.

Precipitation Acidity

Acidic precipitation is defined as rainfall with a pH value of less than 5.6. Uncontaminated precipitation has a pH value of 5.6. The pH of most rain in Alberta is 5.5. Acid rain is mainly caused by emissions of sulphur oxides and nitrogen oxides, which chemically react in the atmosphere to produce sulphuric acid and nitric acid. These acids can fall to earth as rain, snow, sleet or hail.

There are naturally occurring circumstances that can affect acid precipitation. Much of Alberta is less susceptible to environmental damage by acid precipitation than is Eastern Canada, because of Alberta's generally alkaline soils and bedrock. Some areas of northeastern Alberta, however, are highly sensitive to acid precipitation.

From 1978 to 1990 the average pH of precipitation in the province was 5.5, close to that of uncontaminated precipitation. Average pH values ranged from 5.0 at Fort Chipewyan to 6.1 at High Prairie. Beaverlodge, Cold Lake, Fort McMurray and Kananaskis recorded average pH values of 5.2 or less for this period.

For the period 1978 to 1990, there was a long-term increase in precipitation acidity at several locations in Alberta. This trend could be the result of improved sampling techniques (i.e., less windblown dust contaminating the samples), or a change in the location of the monitoring site.

In 1992, the most acidic (i.e., lowest pH) precipitation was recorded at the Fort McMurray precipitation monitoring station, where an annual average pH of 4.7 was observed. At Beaverlodge, Cold Lake, High Prairie, Fort Chipewyan, Fort Vermilion, Red Deer and Kananaskis, pH values from 5.0 to 5.2 were measured. Calgary and Suffield recorded annual average pH values close to that of uncontaminated precipitation (pH of 5.6). Annual pH values higher than 5.7 were not recorded at any monitoring stations in 1992.

Carbon Dioxide and Other Greenhouse Gases

The greenhouse effect is a natural phenomenon that is essential for life on earth. Heat from the sun penetrates the earth's atmosphere to be absorbed by its surface. Some of this heat radiates back through the atmosphere, and is captured by greenhouse gases, such as carbon dioxide. The greenhouse gases act like a blanket to keep the surface of the earth warm. Without the greenhouse gases, all radiated heat would be lost into space and the surface of the earth would be cold and barren.

Human generated emissions are increasing the amounts of greenhouse gases in the atmosphere. This increase means that more of the energy radiated from the earth is trapped. Man-made greenhouse gases include those manufactured (e.g., chlorofluorocarbons) and those released as a result of human activity. The three main greenhouse gases are carbon dioxide, methane and nitrous oxide. Greenhouse gas emissions for 1990 are shown below:

Carbon Dioxide	114 512 kilotonnes
Methane	2629.4 kilotonnes
Nitrous Oxide	27.2 kilotonnes

Not all of the greenhouse gases make an equal contribution to the greenhouse effect (Figure 3.7). One molecule of methane has over eleven times the global warming potential of a molecule of

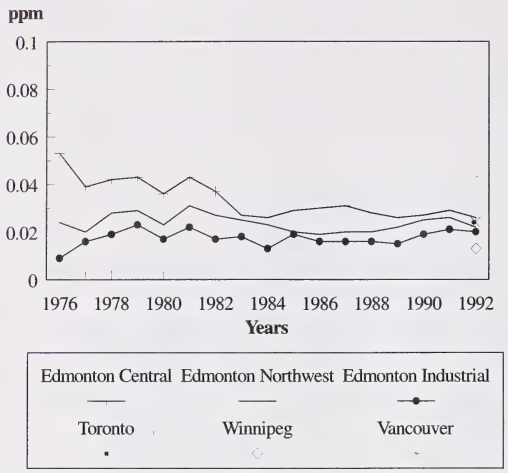


Figure 3.6A Average Annual Nitrogen Dioxide Concentrations - Edmonton and Selected Canadian Cities.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

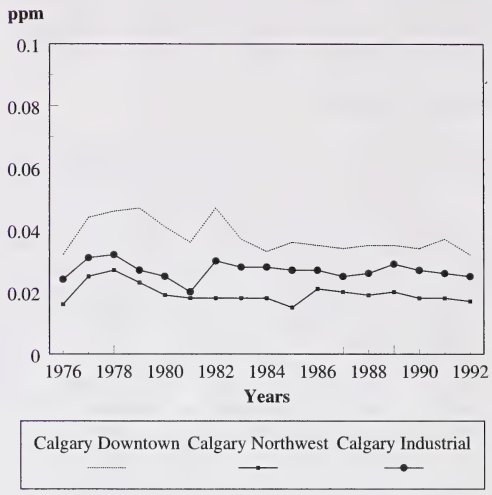


Figure 3.6B Average Annual Nitrogen Dioxide Concentrations - Calgary.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

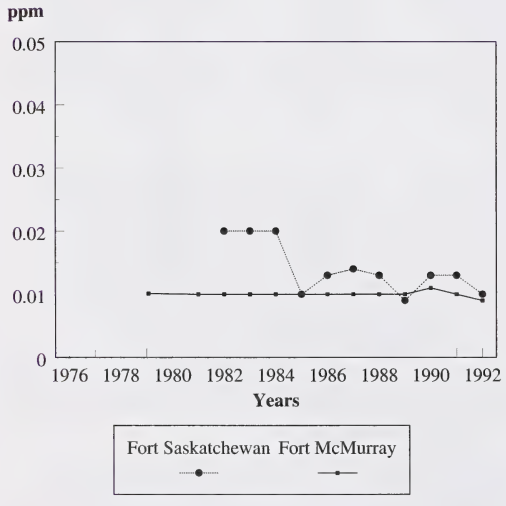


Figure 3.6C Average Annual Nitrogen Dioxide Concentrations - Northern Alberta.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

carbon dioxide; nitrous oxide 270 times; ground level ozone 2000 times; and chlorofluorocarbons 13 000 to 20 000 times.

Carbon dioxide is produced through the combustion of fossil fuels. Natural sources of carbon dioxide include the respiration processes of micro-organisms and plants.

Alberta Environmental Protection began monitoring carbon dioxide in downtown Calgary in March, 1991 and at Springbank (20 kilometres west-northwest of downtown Calgary) in August 1991. Average concentrations of carbon dioxide at the Calgary downtown and Springbank stations were 391 and 371 parts per million, respectively. Higher carbon dioxide concentrations in downtown Calgary are related to fossil fuel combustion in Calgary. In Alberta, carbon dioxide has not been monitored for a long enough period to determine a trend.

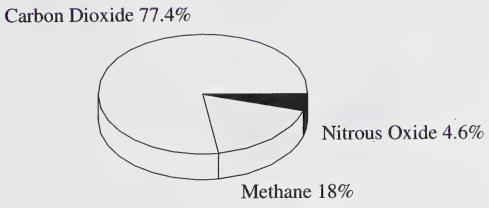


Figure 3.7 Relative Contribution of Greenhouse Gases in Alberta.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

B. STRESSES

The current condition of the environment is influenced by natural and human activities. Identified below are some of the influences of these activities.

Common Pollutants

Industrial activities release emissions to the environment. Figure 3.8 shows how different industries contribute to "common pollutant" emissions. Of the 1990 emissions of carbon monoxide in Alberta, nearly 40 percent result from electricity generation. Oil and gas production, along with miscellaneous industry sectors, are the other major contributors. Of the particulate matter emissions, electricity generation and miscellaneous industry accounted for close to 95 percent. Chemical plants were the main sources of VOCs in 1990, accounting for close to a third. The primary contributors of nitrogen oxides emissions were the oil and gas industry, which accounted for about one-half, and electricity generation, which accounted for one-third. With regard to sulphur dioxide emissions, oil and gas production and electricity generation were the main sources, accounting for (respectively) three-quarters and just under one-quarter of the total.

The figures described above provide a snapshot of industrial sources for common pollutants. The relative contribution of industries changes over time for various reasons. Emissions of sulphur dioxide from the oil and gas industry have dropped because of improved sulphur recovery technology, while gas production has climbed. Emissions from electricity generation have increased because more generating plants have come on-line to meet consumer demands.

Industrial processes are not the only sources of common pollutants. Transportation and residential fuel combustion are large sources of pollutants. In fact, automobiles and light duty trucks alone emit an estimated four times the amount of industrial emissions of carbon monoxide, 15 percent as much VOCs and almost 10 percent as much oxides of nitrogen.

Carbon Dioxide and Other Greenhouse Gases

Canada produces about two percent of the world's energy-related carbon dioxide emissions, but on a per capita basis is one of the world's highest emitters. Contributing factors to Canada's carbon dioxide emissions include energy-intensive export industries, geography, cold climate and lifestyle.

Table 3.1 shows how the energy sector contributed to the province's carbon dioxide emissions in 1990. Natural gas and petroleum use made up the largest percentage of the total emissions. This includes emissions associated with transportation, and industrial, commercial and residential heating. The use of coal to generate electricity for utilities contributed about 31 percent of total emissions.

Carbon dioxide emissions are also generated in the production of fossil fuels, particularly in natural gas processing and synthetic oil production. In 1990, emissions from fossil fuel production accounted for about 26 percent of total emissions. Oil refining and transport make up the remaining 4 percent of the total provincial emissions (Table 3.1).

Between 1988 and 1990, the emissions of carbon dioxide in Alberta decreased. The recession that was occurring throughout North America during 1990 is related to this reduction. The slowdown in economic activity resulted in less energy being consumed, both for domestic purposes and for energy exports.

Alberta's 1990 inventory of greenhouse gases estimates that Alberta emitted 2600 kilotonnes of methane in 1990. It was estimated that fossil fuel production resulted in 811 kilotonnes of methane,

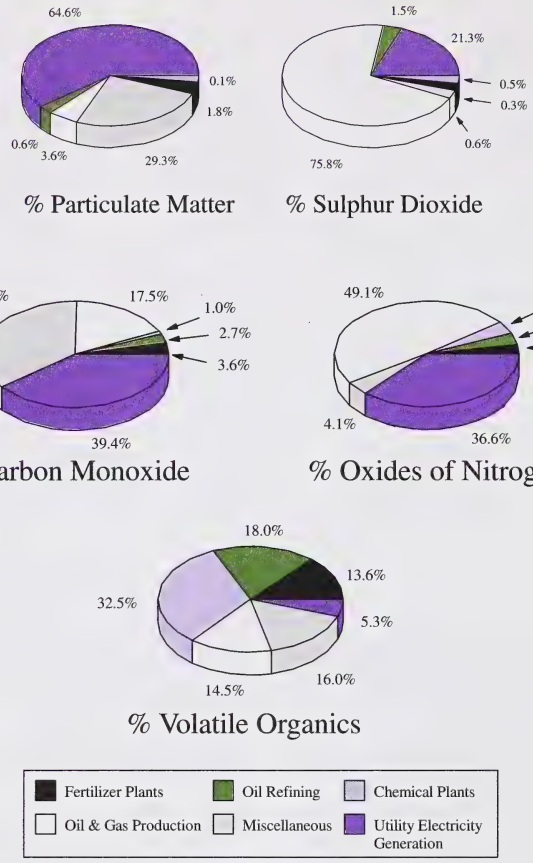


Figure 3.8 Industrial Alberta Atmospheric Emissions for 1990.

Source: Environmental Regulatory Services, Alberta Environmental Protection.

whereas 1800 kilotonnes were the result of biologically related emissions such as animals and vegetation (Table 3.1).

The same inventory estimates that Alberta emitted 27.2 kilotonnes of nitrous oxide, a powerful greenhouse gas. It was estimated that fossil fuel production resulted in 8.6 kilotonnes of nitrous oxide, whereas 18.5 kilotonnes were the result of other biological processes.

Chlorofluorocarbons

Depletion of the stratospheric ozone layer has been attributed primarily to human-made chemicals, especially chlorofluorocarbons (CFCs). Alberta's use of CFCs was estimated in 1986 to be about 2000 tonnes per year. Of this, two-fifths were used in refrigeration and air conditioning, one-third in foam blowing and one-eighth in cleaning solvents. Companies using foam blowing in Alberta have stopped using CFCs. Annual use of CFCs can be expected to drop as they are replaced by other

Table 3.1 Alberta Greenhouse Gas Emissions in 1990.

EMISSION SOURCE SECTOR	CO_2	CH_4
Fossil Fuel Emissions	-kilotonnes-	
Fossil Fuel Production	35 008	799.1
Oil Refinery and Transport	4 886	6.8
Utility Electricity Generation	38 100	1.1
Natural Gas and Petroleum Product Use		
Cars, Trucks, Planes	20 470	3.2
Industry, Fuel, Processes	12 413	1.1
Commercial, Residential, etc.	12 269	0.3
Fossil Fuel Subtotal	123 146	811.6
Inorganic Resources Utilization Subtotal	1 240	0.0
Biological Emissions		
Wood Industries and Fuel Use	3 384	0.4
Fermentation	29	0.0
Wastes (including Landsfill and Fires)	1 827	32.9
Fertilizer Use	0	0.0
Animals	762	263.1
Vegetation	(15 876)	1 521.4
Biological Emissions Subtotal	(9 874)	1 817.8

Source: Environmental Regulatory Services, Alberta Environmental Protection.

compounds as a response to national and international requirements. CFCs are not produced in Alberta.

C. ACTIONS

Some examples of control activities include the following:

- regulation;
- urban planning;
- airshed management;
- agreements with the United States on transboundry pollution;
- National Air Issues Coordinating Committee; and
- international guidelines developed by the United Nations.

In Alberta, environmental regulations are based on preventing detrimental effects to the environment before they occur. Regulations on air quality, therefore, are based on controlling air pollution at the source and allowing for the dispersion of any residual emissions. All emitters of air pollutants are required to use the best available demonstrated technology to reduce the amount of pollutants released to the environment. Industries are required to monitor their own emissions and the air quality near the source of the emissions. Industries report monitoring results to Alberta Environmental Protection on a monthly basis.

Alberta has ambient guidelines for air pollutants under the *Environmental Protection and Enhancement Act*. These air pollutants include sulphur dioxide, hydrogen sulphide, nitrogen dioxide, carbon monoxide, ground-level ozone, suspended particulates (all discussed earlier in this section), dust, ammonia, hydrogen sulphide and fluorides.

Clean Air Strategic Alliance

In March 1994, the Alberta Ministers of Energy and Environmental Protection announced the establishment of the Clean Air Strategic Alliance (CASA), a unique partnership of industry, government, environmental groups and other key stakeholders. The CASA is responsible for the development and implementation of a Comprehensive Air Quality Management System for Alberta. The CASA will:

- identify air quality issues;
- prioritize specific problems;
- allocate and coordinate resources to tackle the issues and problems;
- develop action plans; and
- evaluate results.

In 1994, CASA developed recommendations for an Alberta Strategic Action Plan on climate change. These recommendations have been approved by the Alberta Government.

Emissions Inventory

Alberta Environmental Protection is committed to maintaining an inventory of emissions to the atmosphere in the province. A complete, accurate, and up-to-date inventory is a required element for local, provincial, national and international management of air pollution. The department's goal is to develop an inventory of industrial common pollutants and greenhouse gas emissions for 1994 with annual updates thereafter. Environmental Protection will continue to assist the federal government in establishing an accurate and consistent national inventory.

National Air Issues

A broad process that has been established to address all air issues across Canada is the National Air Issues Coordinating Committee. The provincial departments of environmental protection and energy are members. The group coordinates federal and provincial activities related to climate change, acid deposition, smog and other atmosphere issues. The focus is currently on developing Canada's National Action Plan on Climate Change.

KEY POINTS

- There is a downward trend in carbon monoxide levels at many Alberta air quality monitoring stations. This trend is due to improvements in automobile engines.

- Levels of suspended particulates have decreased at all urban monitoring stations, due to less road dust and improvements in automobile engines.

- The levels of lead have decreased at all monitoring stations, mainly because of the banning of leaded gasoline.

- Ground-level ozone concentrations are generally lower in Alberta cities because this pollutant is destroyed by nitric oxide from automobile emissions.

- Levels of nitrogen dioxide show little change from the historic average.

- There is no discernible trend in the atmospheric concentrations of sulphur dioxide.

- There has been a long-term increase in precipitation acidity in Alberta. This could be the result of improved sampling techniques, or a change in the location of the monitoring sites.

- Transportation is a major source of carbon monoxide.

- Industrial plants are contributing emissions to the atmosphere. The major contributors are:
  -carbon monoxide through electricity generation, oil and gas production;
  -suspended particulates through electricity generation;
  -VOCs through chemical plants;
  -oxides of nitrogen through oil and gas production, oil refining, electricity generation;
  -sulphur dioxide through oil and gas production, electricity generation; and
  -carbon dioxide through electricity generation, natural gas and petroleum use, fossil fuel production.

- Estimates of methane emissions vary widely. Coal production and burning, well blowouts and fuel combustion, as well as cattle, sheep, pigs, horses and wild grazing animals, all contribute to annual methane emissions.

FUTURE DIRECTIONS

- The Clean Air Strategic Alliance, a partnership of industry, government, environmental groups and others, is addressing atmosphere issues through the development of action plans.

- Alberta Environmental Protection will complete the development of an emissions inventory. This inventory, which will consider key industrial and greenhouse gas emissions, will be updated annually by the department.

- Alberta Environmental Protection and Alberta Energy will, through the National Air Issues Coordinating Committee, work on developing Canada's National Action Plan on Climate Change.

4.0 WATER

Stewardship of Alberta's water resources is a complex undertaking. Rivers, lakes and groundwater cannot be managed separately, since these various water sources are more or less interconnected. Stresses inflicted on a local water body may impact water resources far downstream. Similarly, actions to improve or enhance the quality of a local water body may have effects throughout the drainage basin. Activities on the land can also affect water quantity and quality.

Major concerns and issues related to water in Alberta include the availability of an adequate supply at times when it is needed in certain parts of the province, the protection of an adequate water supply for aquatic ecosystems, surface water and groundwater contamination, and flooding.

A. PRESENT CONDITIONS

Rivers

Quantity

The amount of water that enters and leaves Alberta through rivers is shown in Figure 4.1, based on 1993 natural flow calculations. Of the 129 697 000 cubic decametres of water leaving Alberta, only 43 percent actually originates within the province. Almost all the rest comes from British Columbia through the Peace River System. About 86 percent of the water leaving the province flows north to the Arctic Ocean through the Slave and MacKenzie river basins, 14 percent flows into Hudson Bay, and less than 1 percent flows into the Gulf of Mexico.

The volume of water flow in each river varies naturally from year to year. The range of flows along major rivers and their tributaries are summarized in Table 4.1 for both natural and regulated conditions, and 1992 flow volumes are compared to historical values. Based on these data, the main stems of the Peace and Athabasca rivers show the least amount of variability in year-to-year flow. The preceding rivers are followed by the North Saskatchewan, Bow, Oldman and Red Deer rivers. The Battle River (because its headwaters are in the prairie environment) and the Beaver River (because it has extensive lake storage) exhibit the greatest degree of variability in flow from year to year. Flows in the Bow, Oldman, Red Deer, Peace and North Saskatchewan rivers are regulated.

The water flow in 1992 was above the historical average for the Hay River, and near the average for the Peace, Red Deer, Athabasca and North Saskatchewan rivers. All other rivers were below average, with the Beaver River experiencing a record low.

Quality

The quality of water in Alberta varies with the season, the year and the location. Indicators of water quality include temperature, and the concentrations of dissolved oxygen, fecal coliform bacteria, nutrients such as phosphorus or nitrogen, metals (such as lead and mercury) and pesticides. One way of assessing quality is to compare measured concentrations of these indicators with provincial or federal water quality guidelines for particular water uses.

To illustrate the variability in water quality, data for four of Alberta's main rivers are summarized in Table 4.2. The following examples discuss some of the water quality problems that occur to a greater or lesser extent in many of Alberta's rivers.

Athabasca River

The amount of oxygen that is dissolved in water is an important indicator of water quality. Pronounced fluctuations in dissolved oxygen levels may be stressful or even fatal to aquatic organisms. If dissolved oxygen concentrations become too low, organisms living in a river or lake become oxygen-stressed and may die.

Recent expansions in the pulp industry have raised concerns about water quality in the Athabasca River. Some of the pulp industry discharges are "oxygen-demanding," (i.e., oxygen is taken up from the water, decreasing dissolved oxygen levels). Some pulp mills discharge chlorinated organic compounds (i.e., compounds that contain chlorine). Chlorinated organic compounds result from the use of chlorine or chlorine dioxide in bleach plants.

Like most northern Alberta rivers, the Athabasca River is mostly ice-covered for 4 to 5 months during the winter, which greatly reduces the

Alberta
ENVIRONMENTAL PROTECTION

Figure 4.1

MEAN ANNUAL NATURAL RIVER DISCHARGES

Total outflow 129,697,000 dam^3
Total inflow 73,534,000 dam^3
Originating in Alberta 56,163,000 dam^3
Inflow and outflow values represent the natural annual volume

Table 4.1 Annual Flow Volumes at Key Location in Major Alberta Rivers.

River Basin	Location	Drainage Area km²	Natural Annual Volume (1912-1988) Maximum
Hay	near Meander R.	36 900	5 130*
	at AB-NWT border	47 900	7 830
Peace	at AB-BC border	118 800	65 000
	at Peace River (town)	186 000	76 400
	at Peace Point	293 000	89 600
	Wapiti R. near Grande Prairie	11 300	5 300
	Smoky R. near Watino	60 300	18 500
Athabasca	near Jasper	3 880	3 600
	near Hinton	9 780	7 260
	near Windfall	19 600	10 500*
	at Athabasca (town)	74 600	23 400
	below Fort McMurray	133 000	27 900
	Clearwater R. above Christina R.	17 000	3 090
	Clearwater R. at Draper	30 800	6 780
Slave	at Fitzgerald	606 000	
Beaver	near Goodridge	4 710	478
	at AB-SK border	14 500	1 920
	Sand R. near mouth	4 910	730
North Saskatchewan	below Bighorn Plant	3 890	3 300
	at Edmonton	28 000	11 500
	at AB-SK border	57 100	12 300
Battle	near Ponoka	1 830	260
	near Forestburg	7 680	663
	at AB-SK border	24 800	1 290
Red Deer	at Burnt Timber Cr.	2 246	1 276
	at Dickson Dam	5 604	2 289
	at Red Deer (city)	11 593	3 945
	at Drumheller	24 800	4 616
	at Bindloss	44 700	4 613
Bow	at Banff	2 210	1 620
	at Seebe	5 170	3 721
	at Calgary	7 860	4 645
	at the mouth	25 300	7 210
	Elbow R. at Calgary	1 230	663
	Highwood R. at Aldersyde	1 570	1 002
Oldman	at Waldron's Corner	1 444	890
	at Brocket	4 402	2 386
	at Lethbridge	17 009	7 015
	Belly R. at Mountain View	319	446
	Waterton R. near Waterton Park	614	875
	St. Mary R. at CAN-USA border	1 210	1 264
South Saskatchewan	at Medicine Hat	56 400	13 760
Milk	at western crossing of CAN-USA border	1 050	201
	at Milk River (town)	2 720	326
	at eastern crossing of CAN-USA border	6 490	481
	North Milk R. at CAN-USA border	238	69

* Data are based on March to October total flows.
Notes: NAT = Natural flow; Q = flow; all flow volumes are in 1000s dam^3.

Source: Water Resources Services, Alberta Environmental Protection.

Table 4.1 (continued).

				Simulated Natural	Recorded/Simulated Annual			
			Natural Flow/	Mean Annual Volume	Volume Since Regulation			Recorded Volume
Mean	Minimum	Qmax/Qmin	Year Regulated	Since Regulation	Maximum	Mean	Minimum	for 1992
2 430*	455*	11	NAT					3 220
3 630	630	12	NAT					4 950
46 800	32 800	2	1968					
60 700	46 200	2	1968	60 700	75 400	60 700	47 600	61 500
68 200	51 500	2	1968	68 200	82 700	68 200	49 500	67 500
3 190	1 650	3	NAT					2 000
11 300	5 900	3	NAT					7 800
2 790	2 270	2	NAT					2 750
5 490	4 450	2	NAT					5 240
7 070*	5 040*	2	NAT					5 930
13 600	9 440	3	NAT					9 720
20 860	14 900	2	NAT					15 000
2 340	1 750	2	NAT					2 140
3 850	2 370	3	NAT					2 530
			1968	108 000	137 000	108 000	81 700	110 000
127	0	3 230	NAT					0
653	64	30	NAT					64
296	41	18	NAT					41
2 510	1 590	2	1973	2 390	3 130	2 390	1 820	2 530
6 750	4 250	3	1973	6 320	9 250	6 320	4 420	5 300
7 160	4 340	3	1973	6 700	9 120	6 700	4 770	5 550
98	15	18	NAT					56
138	14	47	NAT					107
275	48	27	NAT					159
733	389	3	NAT					610
1 100	603	4	1983					
1 503	659	7	1983		2 310	1 313	684	1 350
1 759	740	6	1983		2 570	1 444	758	1 440
1 842	756	6	1908		4 620	2 003	911	1 620
1 250	884	2	NAT					1 040
2 544	1 762	2	1911			2 510		2 300
2 909	1 882	3	1911	2 900	4 640	2 886	1 840	2 460
3 960	2 350	3	1910					2 380
299	135	5	1932	293	564	213	63	204
442	155	7	1911	442	997	434	150	350
475	183	5	NAT					272
1 252	443	5	1992					480
3 425	1 420	5	1910	3425	6 730	2 800	526	792
289	164	3	1935	288	439	266	134	169
579	313	3	NAT					349
796	442	3	1916		1 201	608	293	373
7 370	3 730	4	1908		13 200	6 110	2 100	3 370
77	13	16	1916	75	199	73	10	29
129	28	12	1916	127	435	289	137	199
167	38	13	1916	165	538	319	144	197
29	10	7	1916					175

introduction of oxygen into the water. Thus, in winter, the water has less dissolved oxygen. Concentrations of dissolved oxygen at various locations in the Athabasca River are shown in Figure 4.2 for the winters of 1990 and 1993.

The effects of the development of forestry and pulp industries on the levels of dissolved oxygen and chlorinated organic compounds in rivers is being investigated as part of the Northern River Basins Study (NRBS). (Additional information on pulp mill discharges and the NRBS is provided in the

Table 4.2 Summary of Water Quality in Four Alberta Rivers, 1991 to 1993.

Constituent	North Saskatchewan R. at Pakan		Bow R. below Carseland Dam		Red Deer R. at Morrin Bridge		South Saskatchewan R. at Highway 41	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Ammonia-Nitrogen	0.04	0.49	0.02	0.46	0.01	0.075	0.0095	0.165
Total Nitrogen	0.79	1.05	0.91	1.93	0.56	0.665	0.225	1.21
Total Suspended Solids	21.8	4.45	8.0	3.2	31	2.6	31.3	5.6
Phosphorus	0.1	0.107	0.042	0.052	0.059	0.06	0.037	0.023
Copper	0.002	0.001	0.002	0.001	0.0015	0.001	0.0017	0.0011
Lead	0.002	0.002	0.002	0.002	0.002	0.002	0.0007	0.0007
Zinc	0.006	0.005	0.005	0.003	0.002	0.0035	0.0038	0.0027
Organic Carbon	4.3	1.9	2.4	1.7	7.7	3.6	4.65	2.83
Fecal Coliforms (MF) (CTS/100mL)	36	250					10	

Notes: All units are in mg/L and are "total" substance unless otherwise indicated. The represent an average of values from 1991 to 1993.
Median concentrations are given. The median concentration is the middle value in a set of data. Summer = May to September; winter = December to March.

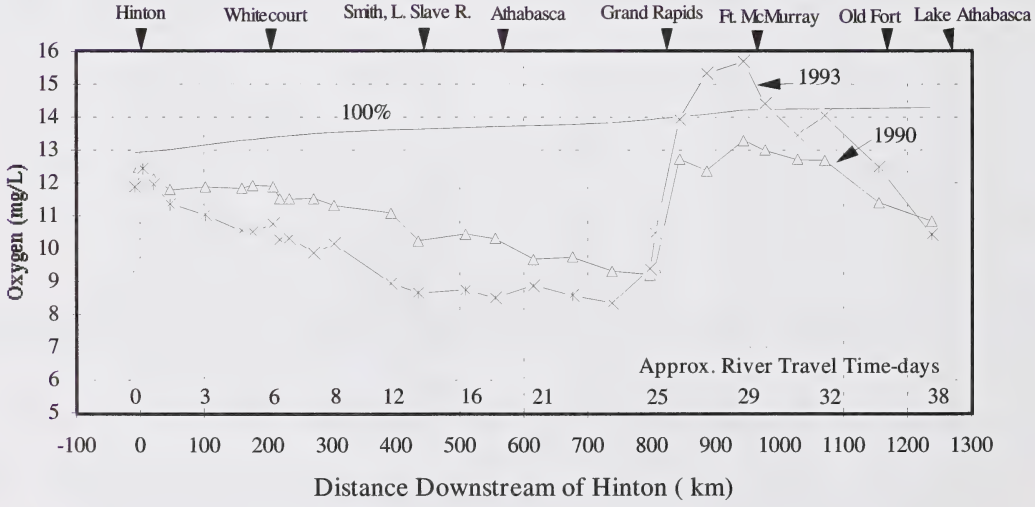


Figure 4.2 Winter Dissolved Oxygen Concentration in the Athabasca River, 1992 and 1993.

Source: Water Resources Services, Alberta Environmental Protection.

following sections on Water Uses and Stresses, and Actions.)

North Saskatchewan River

Water quality in the North Saskatchewan River reflects its source in the Rocky Mountains, its passage through different regions and the impacts of various human activities. The most obvious change in water quality occurs in the Edmonton-Fort Saskatchewan area. In this area, levels of indicators such as phosphorus, nitrogen and fecal coliform bacteria increase in the river as a result of various effluent discharges.

Table 4.3 shows how water quality in the North Saskatchewan River varies over distance. Data are shown from Devon (upstream of Edmonton), at Pakan (100 km downstream of Edmonton) and at the Alberta-Saskatchewan border. Most parameters were similar or lower in 1992 than the long-term medians (1978 to 1989). In 1992, concentrations of these substances complied with Canadian Water Quality Guidelines for the protection of aquatic life, except for one value of lead at Devon.

Bow River

In response to increasing public concerns about problems with Bow River water quality, a Bow River Water Quality Task Force was appointed in 1990. The task force published a report in 1991 and expressed concern about levels of pathogenic bacteria, viruses and parasites all along the river, especially in reaches downstream of Calgary. Also of concern were organic contaminants, night-time dissolved oxygen, and nutrient and ammonia levels in the river within and below Calgary. The task force also provided recommendations to improve and protect the water quality.

For the Bow River below Calgary, dissolved oxygen levels in summer are very high during the day and low at night (Figure 4.3). Such fluctuations over a 24-hour period are related to the natural balance between oxygen-producing processes like photosynthesis and oxygen-consuming processes like respiration. This variability is commonly observed in southern Alberta rivers, at locations where there are many aquatic plants.

Table 4.3 Summary of Water Quality in the North Saskatchewan River, Long-Term (1978 to 1989) and 1992.

	Devon		Pakan		Border		CWQG	1992 Compliance		
Constituent	Long-term	1992	Long-term	1992	Long-term	1992		Devon	Pakan	Border
Ammonia-Nitrogen	<0.1	0.01	0.207	0.11	0.131	0.051	0.23-2.2	12/12	12/12	12/12
Total Nitrogen	0.26	0.27	0.88	0.81	0.94	0.55	NA			
Total Suspended Solids	8.8	3.75	12	6	8.8	9.2	NA			
Phosphorus	0.012	0.008	0.112	0.100	0.087	0.056	NA			
Copper	0.002	0.001	0.002	0.001	0.002	0.001	0.003	7/7	7/7	12/12
Lead	<0.001	<0.002	<0.001	0.002	<0.002	<0.0007	0.004	6/7	7/7	12/12
Zinc	0.003	0.003	0.005	0.005	0.004	0.003	0.03	7/7	7/7	12/12
Organic Carbon	2.6	2.4	3.0	3.3	5.0	3.06	NA			
Fecal Coliforms (MF) (CTS/100 mL)	<4	4	160	68	9	12	NA			

Notes: Median concentrations are given. Units are milligram per litre (mg/L) and "total" substance unless otherwise indicated. CWQG = Canadian Water Quality Guideline (mg/L) for protection of aquatic life; Compliance = number of samples that meet guidelines; NA = no objective available or data inappropriate to test; CTS = Counts.

Source: Water Resources Services, Alberta Environmental Protection.

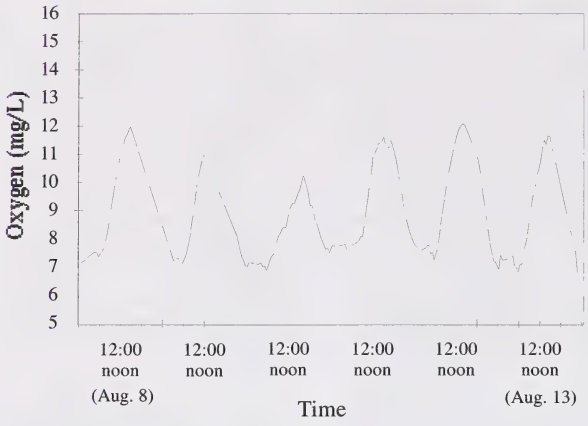


Figure 4.3 Bow River at Stier's Ranch - Daily Oxygen Levels.

Note: Downstream of Calgary, August 8 to 13, 1993.

Source: Water Resources Services, Alberta Environmental Protection.

Lakes

Water Levels

Lake levels vary constantly as a result of numerous natural forces: wind, sun, rain, snow, beaver activity and changes in the water table. Short-term water level fluctuations depend on whether a particular season is wet, dry or average. A decrease or increase in water level may continue for several years, depending on the weather patterns. An example is the decline in water levels in many lakes in the Cold Lake area as a result of below normal runoff from spring snowmelt in the past few years.

Water Quality

There are many different types of lakes in Alberta. They range from shallow lakes (typical of central Alberta) to deep, clear lakes such as Cold Lake, northeast of Edmonton. Some lakes, such as Miquelon and Buffalo lakes, have a high concentration of dissolved substances and are considered saline. Others, like Gregoire and Athabasca lakes, are low in dissolved substances. These differences in lake water quality result from variations in lake size and depth, soils, climate, vegetation, the size of the drainage basin surrounding the lake, and groundwater input. A lake that is shallow and surrounded by fertile soils tends to be highly productive (i.e., it has a lot of plant growth), whereas a lake that is deep and has a large volume of water flowing in and out tends to be clearer.

Alberta lakes can be classified according to low, moderate, high and very high productivity, based on either phosphorus concentrations (which indicate the fertility of the lake) (Figure 4.4) or chlorophyll *a* concentrations (which indicate the amount of algal growth in the lake) (Figure 4.5). Lakes with low levels of phosphorus or chlorophyll *a* are oligotrophic (low productivity). These lakes tend to be clear and more desirable for recreation than lakes with high levels of phosphorus and chlorophyll (hypereutrophic, or very high productivity). Moderately productive lakes are classified as "mesotrophic," and productive lakes are considered "eutrophic."

Over time, most lakes stay in the same general trophic (productivity) category. Their water quality shows slight variability from year to year. For example, variability in water quality (as indicated by chlorophyll levels) for four different lake types is illustrated in Figure 4.6. The two productive lakes have greater year-to-year variability in water quality than the less productive lakes. Other than the year to year variability, however, there has been no long-term change in the water quality of any of these four lakes.

Water quality of lakes can be influenced by human activities. If the land surrounding a lake is cleared, the amount of nutrients entering the lake in runoff water can increase. This "nutrient loading" promotes the growth of algae and shoreline vegetation. In many shallow lakes, the lake bottom sediments play a major role in water quality. Nutrients stored in these sediments return to the water in midsummer when the water is warm. These nutrients promote the growth of blue-green algae, which form the unpleasant scums known as algal blooms.

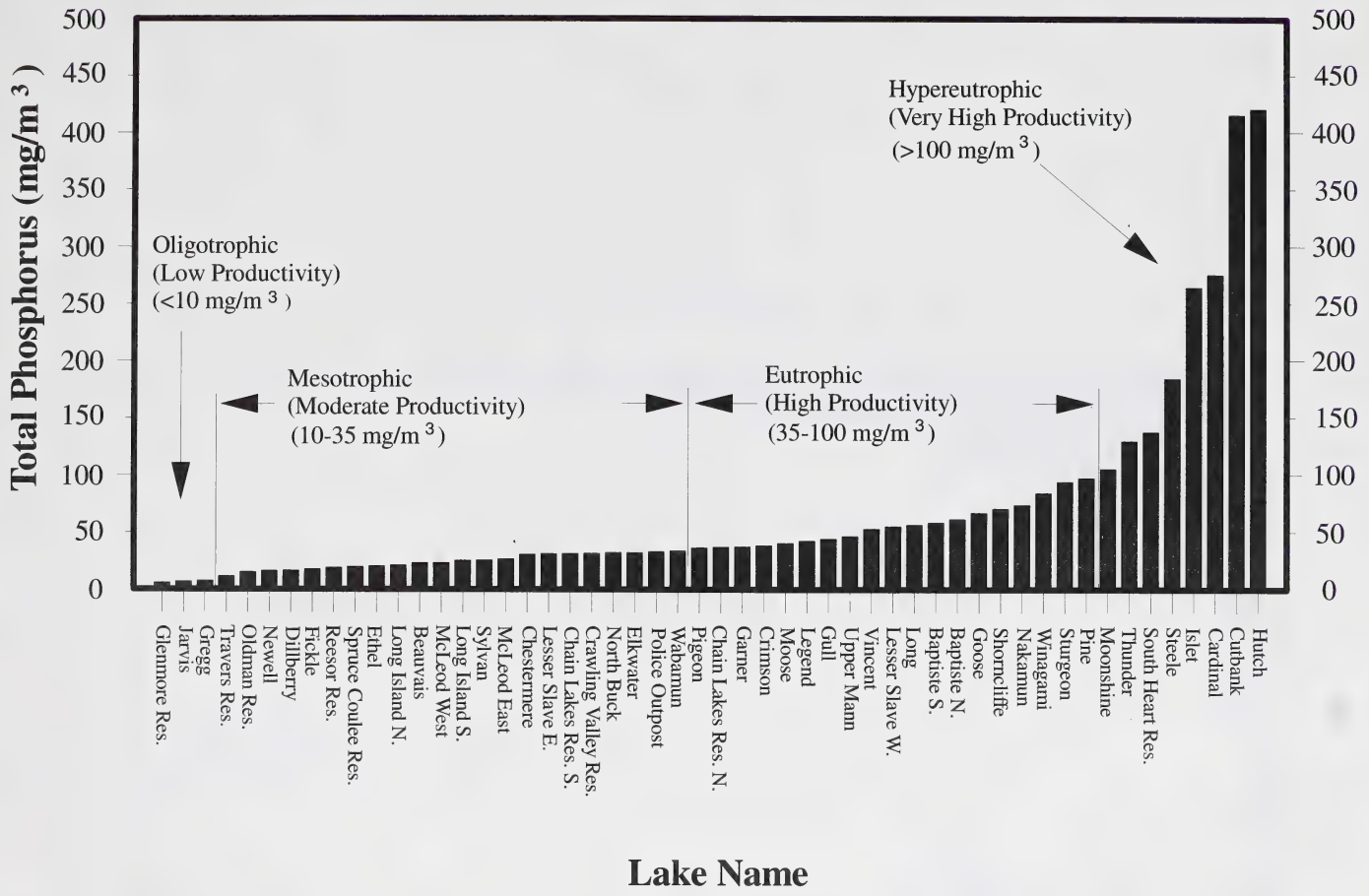


Figure 4.4 Approximate Trophic Categories for Alberta Lakes Based on Average Summer Total Phosphorus Concentrations.

Note: 1992 - 93 data.

Source: Water Resources Services, Alberta Environmental Protection.

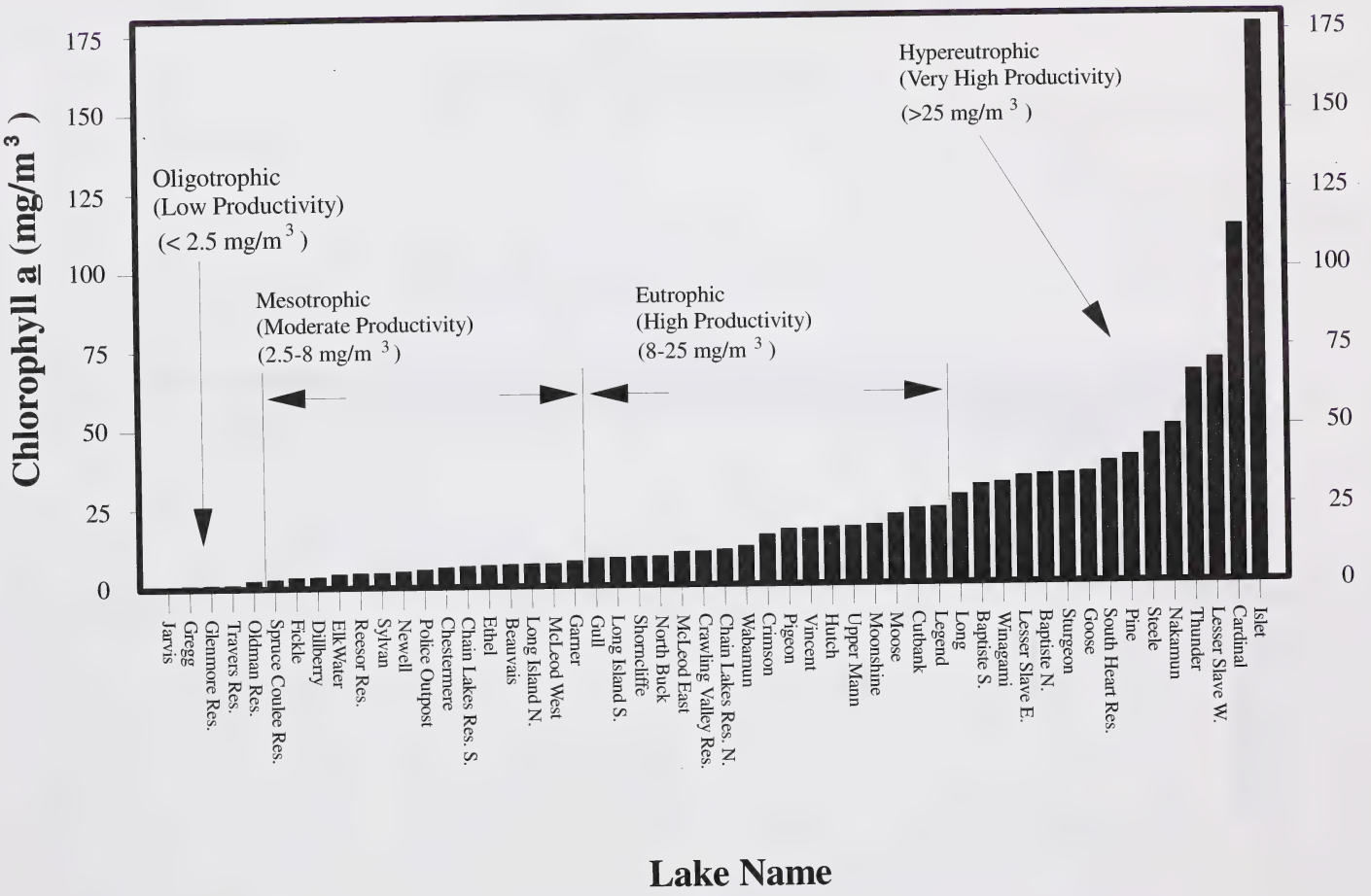


Figure 4.5 Approximate Trophic Categories for Alberta Lakes Based on Average Summer Chlorophyll a Concentrations.

Note: 1992 - 93 data.

Source: Water Resources Services, Alberta Environmental Protection.

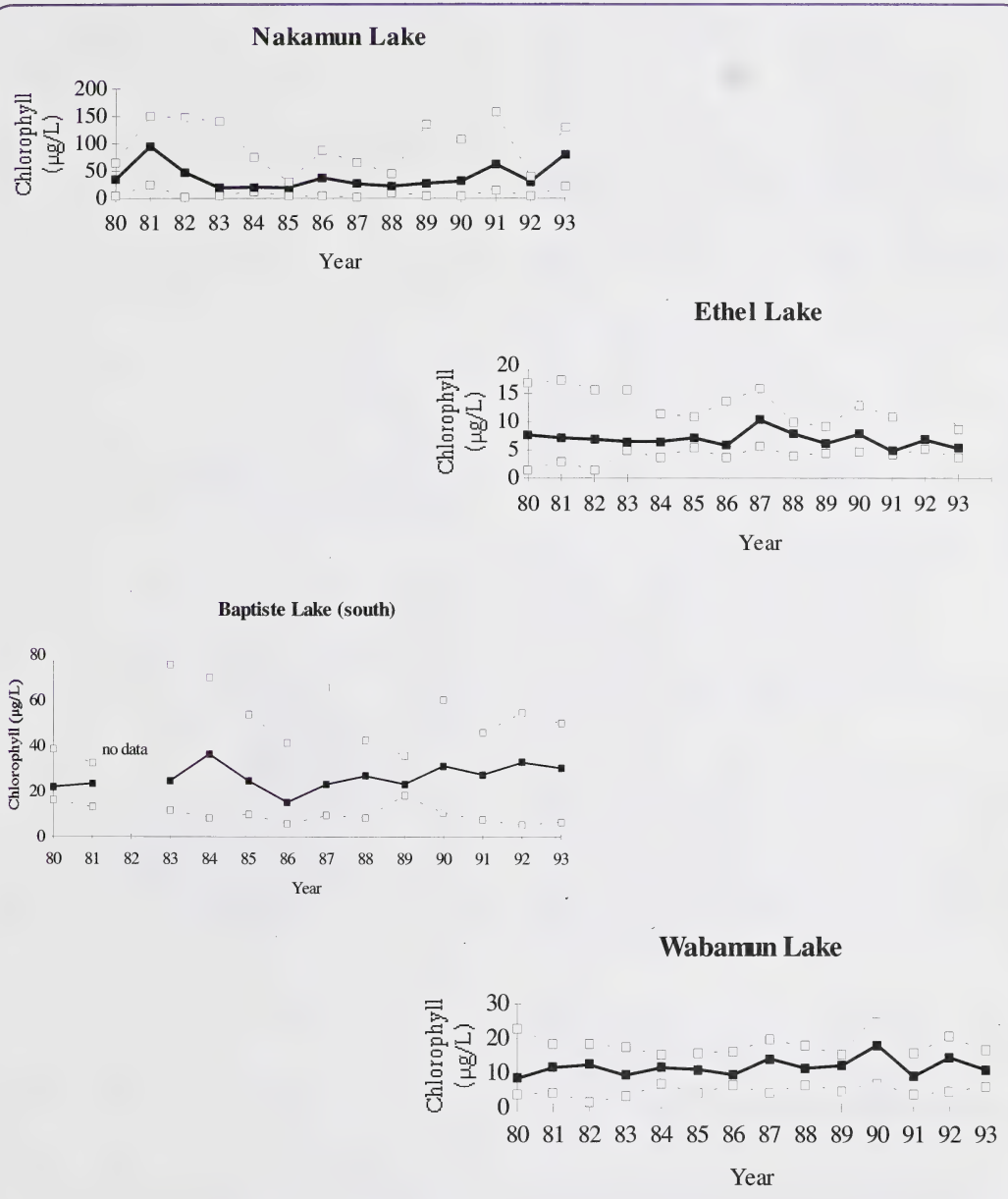


Figure 4.6 Euphotic Chlorophyll a Concentrations in Four Alberta Lakes, May to October, 1980 to 1993.

Notes: Median concentration for each year is represented by the solid line, maximum and minimum values are represented by the dashed lines. Note changes in scale of chlorophyll concentration.

Source: Water Resources Services, Alberta Environmental Protection; and University of Alberta, Department of Zoology.

As a result of human activities, productivity in a lake may change significantly shifting it from one trophic category to another. One example of such shifting is Lake Newell Reservoir, which changed from eutrophic to mesotrophic as a result of reduced phosphorus concentrations in the Bow River from improved sewage treatment in Calgary. Another example is Thunder Lake, which shifted from eutrophic to hypereutrophic as a result of increased nutrient loading from a diversion (Figure 4.7).

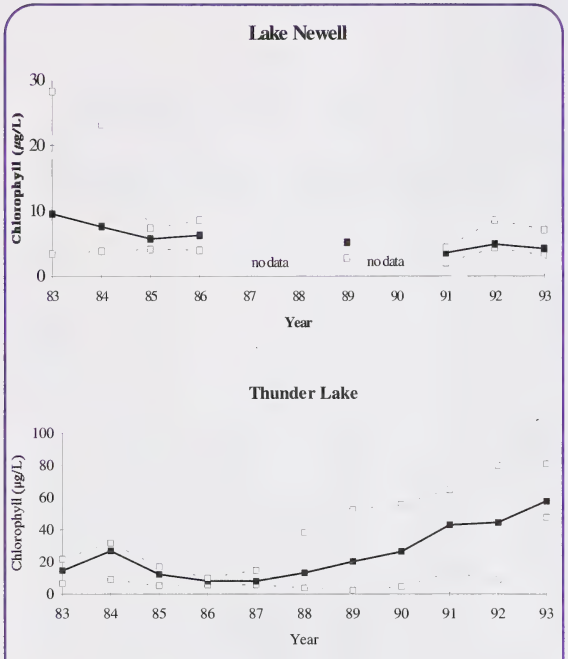


Figure 4.7 Changes in Chlorophyll Concentration in Lake Newell and Thunder Lake.

Note: Median concentration for each year is represented by the solid line, maximum and minimum concentrations are represented as dashed lines.

Source: Water Resources Services, Alberta Environmental Protection.

Groundwater

Quantity

Groundwater is stored in reservoirs called aquifers. Aquifers are layers of water-bearing rocks that allow water to flow through pores and fractures.

Sand and/or gravel aquifers are important in central and northern Alberta, whereas bedrock aquifers predominate in the Plains region of the province. Sand and gravel aquifers include preglacial sand and gravel channels. More than 17 000 kilometres of these channels have been recognized and partially mapped in Alberta.

The total quantity of potable (i.e., drinkable) groundwater stored in sand and gravel aquifers in Alberta is estimated to be more than 100 million cubic decametres. Some 30 million cubic decametres of water are stored in sands that fill the 400-kilometre long Wiau Channel that has been recently discovered in northern Alberta.

Bedrock is usually porous and capable of storing water. The most prevalent bedrock aquifer in Alberta is the Paskapoo Formation, a 760-kilometre by 180-kilometre wedge that borders the eastern edges of the foothills. It contains an estimated 5 billion cubic decametres of potable water. There is another estimated 50 billion cubic decametres of water in the rock formations that occur below the Paskapoo Formation. It is thought that fractures, tubes, tunnels, caves and other openings in the limestones of the Rocky Mountains contain another 200 million cubic decametres of water.

Quality

A key factor in the quality of groundwater is the dissolving of minerals. As a result of dissolved minerals, shallow groundwater in the province is often alkaline, or contains dissolved sulphur or iron; deep groundwater is typically salty and may contain sulphates, chlorides and other dissolved minerals. The concentration of minerals in groundwater is determined by the temperature of the underground environment, the type of rock in which the groundwater resides and the length of time that the water has been stored. Water in deep bedrock is mineralized to such a degree that it is only suitable for limited uses by the petroleum industry.

B. WATER USES AND STRESSES

Water Management Issues

In Alberta there is an imbalance between the area of greatest water supply and that of the greatest water demand. Northern Alberta has about 85 percent of the total water supply, but only about 20 percent of the water demand; the southern half of the province has about 14 percent of the total water supply but 80 percent of the total water demand.

Water is withdrawn from rivers, lakes and groundwater in Alberta to meet a variety of needs. For 1993, withdrawal of over 6.8 million cubic decametres of water has been licensed within the province. The distribution of licensed water use among the primary drainage basins is shown in Figure 4.8.

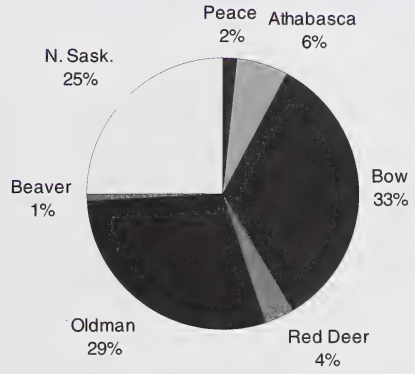


Figure 4.8 Distribution of the Licensed Water Use Within Primary Drainage Basins in Alberta.

Source: Water Resources Services, Alberta Environmental Protection.

Water uses vary, depending on the activities within each river basin (Figure 4.9). Some water is returned to its source after use and is thus available to fulfil demands further downstream. Agriculture, especially irrigation-based, is the primary water user in Alberta.

The rapid pace of development and the increased standard of living in Alberta have resulted in high demands for water. A number of river basins are considered either fully allocated or approaching full allocation because of the increasing demands for water. Alberta has a good supply of water, but it may not be available in the right quantity and quality, at the right place and at the right time to meet human expectations. Most of the demand for water, especially in Southern Alberta is for irrigation. Water demand is highest in June and July, whereas river flows peak in May.

Of all the water under licences for use in Alberta, less than 3 percent is groundwater. This percentage is relatively low in comparison to groundwater usage rates in parts of the United States and Europe. In Alberta, dependence on groundwater use is growing with continued agricultural, industrial and tourism development. Groundwater is of constant quality and temperature, and for small- to medium-scale uses, it is readily available in the province. Because groundwater moves slower than surface water, it is not affected as quickly by short-term weather changes. Climatic changes, however, may ultimately affect groundwater supplies. Groundwater may also be subject to pollution. Once pollution of groundwater occurs, the groundwater can be more difficult to clean than surface water.

In addition to demands within the province, Alberta has obligations to ensure that specified volumes of water are passed to Montana and Saskatchewan. The Milk and St. Mary rivers in southern Alberta, and the Battle, Lodge and Middle creeks in the Cypress Hills are subject to the 1909 Boundary Waters Treaty and a 1921 Order of the International Joint Commission.

Alberta has also signed the 1969 Master Agreement on Apportionment, which applies to the rivers flowing eastward into Saskatchewan. Under this agreement, the province has obligations to ensure that specified volumes of water are passed annually to Saskatchewan. Recently, a water quality agreement has been signed and added to the Master Agreement, specifying certain water quality objectives at border crossing points.

Although water is licensed for various uses, the basic "instream needs" of rivers and lakes must be protected. Instream needs are the water quantities and qualities needed to maintain the ecological integrity of rivers and lakes and to meet the demands for other water uses (e.g., fisheries protection and recreation).

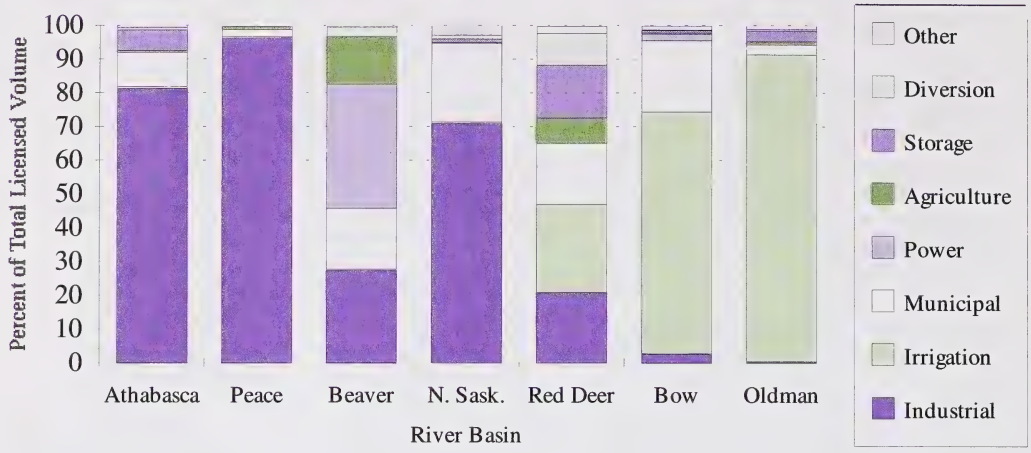


Figure 4.9 Distribution of Water Volume Among Uses in Alberta.

Note: Diversion refers to drainage, alignment and flood control; Storage refers to flow control, lake stabilization, recreation, fire protection and fur farming; Agriculture refers to feedlots, stockwatering and greenhouses; Power refers to flow control for power generation; Municipal refers to urban and subdivision water supplies; Irrigation is for the growing of agricultural crops; Industrial refers to processing, injection, cooling, spill control and gravel washing operations.

Source: Water Resources Services, Alberta Environmental Protection.

Effluent Discharges

Effluent discharges from municipalities and industries vary regionally and seasonally. However, some rivers are naturally more capable of assimilating effluent than others, and can thus handle greater loads. Total effluent loads (from all municipal and industrial sources for which data are available) for the major river basins are summarized in Table 4.4. The relative proportion of nutrients contributed by industry (specifically, pulp mills) and municipalities compared to background (or natural) levels during winter and summer are illustrated for the Athabasca and the Smokey/Wapiti river basins in Figures 4.10 and 4.11, respectively.

Pulp Mill Discharges

The estimated and actual discharges of various parameters to Alberta surface waters are shown in Figure 4.12 for the period from 1957 to the present. Data from 1957 and 1973 are not as reliable as data from more recent years, and have been indicated as estimates. Total pulp mill production in Alberta is based on declared design capacity.

Kraft mills discharge chlorinated organics as a result of the use of chlorine or chlorine dioxide in their bleach plants. Mechanical mills do not use chlorine and produce a different kind of pulp. Three out of four Alberta kraft mills have substituted chlorine dioxide in place of chlorine in their bleach plants. Using chlorine dioxide produces only one-fifth to one-tenth the amount of chlorinated organics that would otherwise be formed. The use of sophisticated technology in most kraft mills further reduces the amount of chlorinated organics.

"AOX" or adsorbable organic halides are used as an indicator of the amount of chlorinated organics produced. Use of this indicator cannot separate chlorinated organic compounds that have potential environmental impacts (such as dioxin) from those components that pose little or no risk. The latter group generally accounts for in excess of 99 percent of the chlorinated organics measured as AOX.

Table 4.4 Loads of Three Substances in Industrial and Municipal Effluents to Major Rivers in Alberta, 1990 to 1994.

River	Season	Total Phosphorus (kg/day)		Ammonia (kg/day)		Total Nitrogen (kg/day)	
		Municipal	Industry	Municipal	Industry	Municipal	Industry
Wapiti/Smoky	summer	49*	59*	108	111	239	387
	winter	49*	59*	108	134	462	239
Athabasca	summer	54	278	297	184	448	745
	winter	56	245	360	276	360	276
North Saskatchewan	summer	1045	40*	5055	421*	6698	889*
	winter	935	40*	4625	421*	8861	889*
Red Deer	summer	124	14*	19	0.2*	662	14*
	winter	130	14*	124	0.2*	582	14*
Bow	summer	295	0	1461	0	6155	0
	winter	334	0	1985	0	6741	0
South Saskatchewan	summer	12	14	83	74	404	123
	winter	20	14	261	80	468	127

Note: Municipal = continuous dischargers only; Industry = licensed industries; summer = May to September; winter = December to March (except for winter values for the Bow River, which are represented by data from October, as no winter data are available); data presented are the median values, except for Wapiti/Smokey rivers, for which seasonal mean values are given.

* = Annual average

Source: Environmental Regulatory Services, Alberta Environmental Protection.

No Alberta kraft mills have had levels of dioxin (2, 3, 7, 8, TCDD) above the Environment Canada limit of 15 parts per quadrillion since 1992 when this limit came into effect. There have been no detectable levels of dioxin in monthly samples collected by the four pulp mills since 1991.

Pesticides and Surface Waters

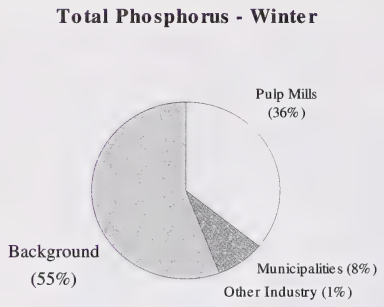
Pesticide is a generic term for any substance used to prevent, destroy or repel any bacteria, insect, nematode, rodent, fungus, weed or vertebrate animal.

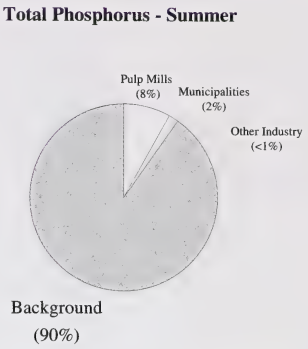
The widespread use of pesticides in agriculture has considerably increased man's ability to produce food (see Section 5.2B). However, the agricultural sector is not the only user of pesticides; industries use herbicides to control weeds at plant sites and along rights-of-way; municipalities and counties apply pesticides along roadsides; and some cities use insecticides for mosquito control. Many private citizens also use pesticides to keep lawns and gardens weed- and "bug"-free.

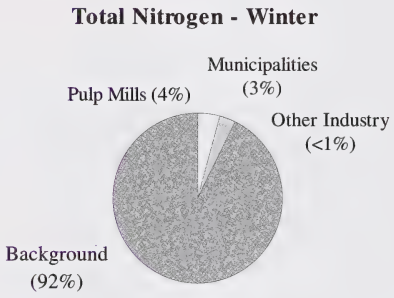
Modern pesticides do not pose the same environmental hazards as some from the past, such as DDT, which were banned when their persistence in the environment and their ability to concentrate along food chains became known. However, there is always risk associated with the introduction of man-made chemicals to the environment. Although the impact on surface waters by pesticides has not been a long-term major concern, the level of concern in Alberta has increased markedly over the past 5 to 10 years.

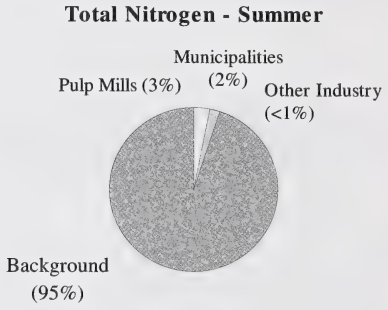
Pesticides may enter lakes and rivers with overland runoff after rainstorms or snow melt; they can leach into shallow groundwater which then feeds into surface waters; or, they can be transported in the atmosphere and deposited with rain, snow and dust. Accidental spills are another possible pathway for surface water contamination.

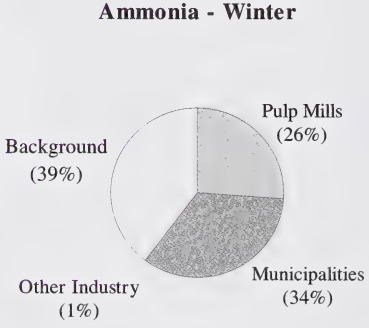
Since 1971, more than 3600 water samples from over 130 river sites across Alberta have been analyzed for pesticide residues by provincial and federal authorities. In total 15 herbicides,











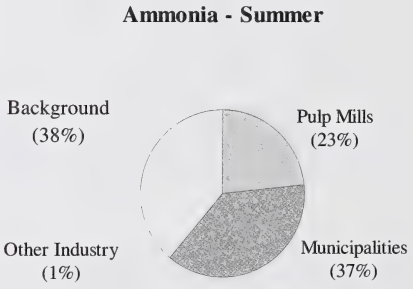


Figure 4.10 Athabasca River Basin Nutrient Loading by Various Sectors.

Source: Environmental Regulatory Services, and Water Resources Services, Alberta Environmental Protection.

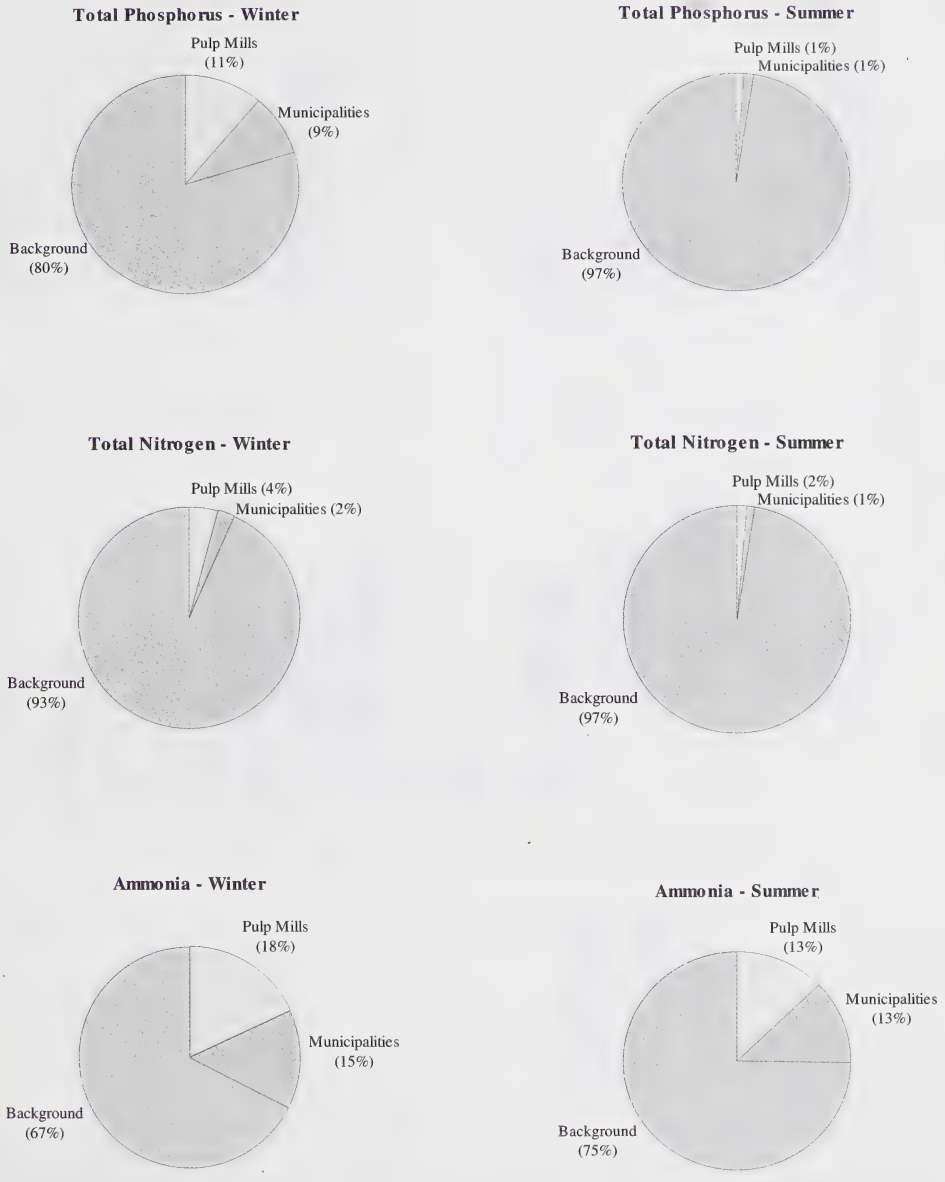
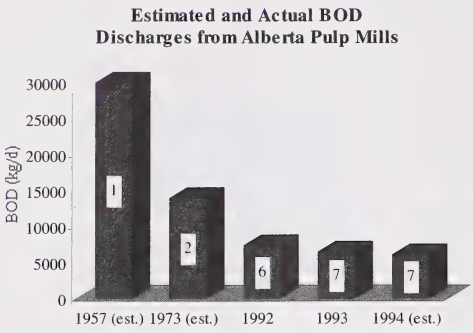
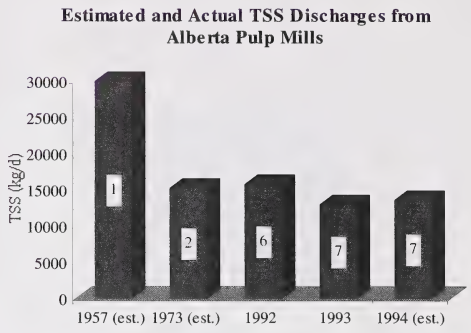
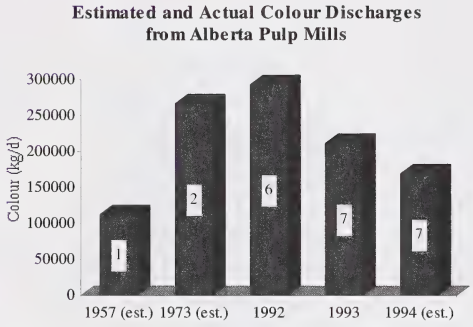


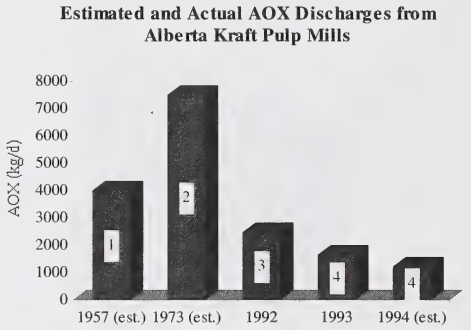
Figure 4.11 Smoky/Wapiti Basin Nutrient Loading by Various Sectors.

Source: Environmental Regulatory Services, and Water Resources Services, Alberta Environmental Protection.









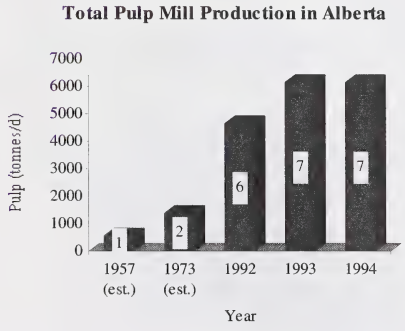


Figure 4.12 Estimated and Actual Pulp Mill Discharges of Various Parameters to Alberta Surface Waters and Total Pulp Mill Production, 1957 to 1994.

Note: The total number of mills contributing to discharges/pulp production are given within each bar; BOD = Biological Oxygen Demand; AOX = Adsorbable Organic Halides; TSS = Total Suspended Solids.

Source: Environmental Regulatory Services, and Water Resources Services, Alberta Environmental Protection.

15 insecticides and 1 fungicide have been detected in these samples (Table 4.5). Most pesticides have been detected in a relatively low percentage of samples except for the following: 2,4-D; 2,4,5-T; lindane; and alpha BHC (all of which have been found in at least 5 percent of the samples). Pesticide concentrations exceeded guidelines for surface water quality in a few samples. However, many pesticides do not have surface water quality guidelines, so it is not possible to assess the significance of their occurrence.

Pesticide concentrations and detection frequencies may also follow seasonal patterns, which reflect the time of year of application. For example, MCPA (2-methyl-4-chlorophenoxyacetic acid) is applied primarily in spring, so detection frequency tends to be highest in July and declines sharply in August (Figure 4.13).

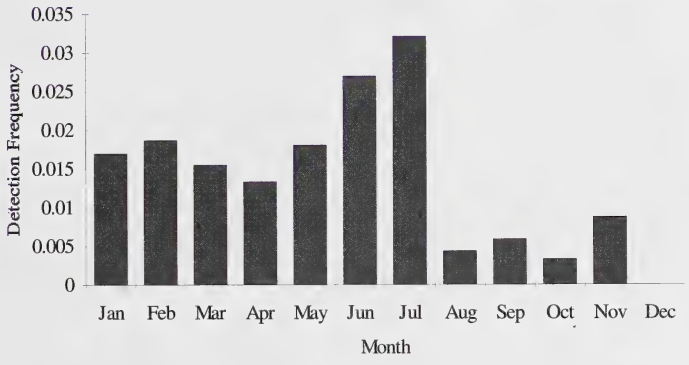


Figure 4.13 Provincial Summary of the Seasonal Pattern in Detection Frequency of MCPA.

Source: Environment Canada.

Although pesticides have been detected within all river basins in Alberta, the frequency of detection is not the same throughout the province: high frequencies of detection tend to correspond to regions of high industrial, municipal and/or agricultural development. For example, lindane, 2,4-D and MCPA have been detected most frequently in the North Saskatchewan, Red Deer, South Saskatchewan and Battle river basins.

Within each drainage basin, pesticides tend to be detected more frequently and at higher concentrations as one moves in a downstream direction. Most pesticides have been detected in the mountain national parks, but concentrations and detection frequencies are usually much lower than elsewhere in Alberta, and can be attributed mostly to atmospheric deposition.

Several factors make evaluation of long-term trends in pesticide use difficult. First, in recent years there have been rapid changes in the types of pesticides marketed. New products have virtually replaced some of the older well-established pesticides, but the types of pesticides that are routinely monitored in surface waters have not changed accordingly. Second, some of the newer pesticides are active at much lower application rates than the conventional products, making routine monitoring of them difficult given current levels of technology.

C. ACTIONS

Legislative Framework

The ownership of all water within the province is vested with the Crown; the diversion and use of water must be authorized under the *Water Resources Act*. There are exceptions to this requirement, the most significant of which is that domestic water supplies may come from any natural source under or adjoining a person's land.

The *Water Resources Act* was prepared in 1931, based largely on the *Northwest Irrigation Act* of 1894, and since that time has undergone only minor revisions. The Act is currently under review to accommodate changing social, economic and water management priorities. Public review of the draft revisions to the Act is currently underway.

The *Water Resources Act* is also used to regulate activities such as the building of roads, bridges, pipeline crossings and permanent docks that could

Table 4.5 Pesticides Detected in Alberta's Surface Waters From 1971 to 1993.

Pestide Type	Active Ingredient	Number of Detections (No. samples)	Detection Frequency (%)	Maximum Detected Concentration	PAL (No. of Non-compliances)	IRR (No. of Non-compliances)
Herbicides	2,4-D	692 (3698)	19	7.4	4 (1)	
	2,4-DP	35 (3490)	1	0.31	NA	
	atrazine	26 (835)	3	32.5	2 (5)	
	bromacil	5 (179)	3	8.7	NA	
	dicamba	9 (1195)	<1	1.15	10	0.006 (4)
	MCPA	40 (3508)	1	2	NA	
	picloram	27 (2052)	1	11.4	29 (0)	
	trifluralin	8 (912)	<1	1.14	0.1 (2)	
	2,4,5-T	140 (3051)	5	0.5	NA	
	triallate	2 (252)	<1	0.01	0.24 (0)	
	MCPB	7 (886)	<1	0.11	NA	
	2,3,6-TBA	1 (884)	<1	0.03	NA	
	silvex	10 (2066)	<1	0.09	NA	
	2,4-DB	11 (2928)	<1	0.09	NA	
	bromoxynil	3 (538)	<1	0.42	5 (0)	0.35 (2)
Insecticides	dursban	4 (178)	2	1.35	NA	
	alpha BHC	1606 (2322)	69	0.023	0.010 (51)	
	lindane	590 (3077)	19	0.05	0.01 (12)	
	pp'TDE	8 (2939)	<1	0.004	NA	
	ppDDE	2 (2937)	<1	0.004	NA	
	heptachlor	5 (2935)	<1	0.0014	NA	
	heptachlor epoxide	1 (2932)	<1	0.002	NA	
	alpha chlordane	1 (2209)	<1	0.001	NA	
	mirex	1 (2105)	<1	0.008	0.001 (1)	
	aldrin	1 (2937)	<1	0.001	NA	
	dieldrin	1 (2935)	<1	0.009	NA	
	disulfoton	4 (329)	1	0.06	NA	
	parathion	3 (406)	<1	0.05	0.008 (3)	
	diazinon	1 (396)	<1	0.1	0.08 (1)	
	ethion	3 (396)	<1	0.12	NA	
Fungicides	HBC	5 (2096)	<1	0.003	0.0065 (0)	

Note: Concentrations are in micrograms per litre (µg/L). PAL = guideline for protection of aquatic life; IRR = guideline for irrigation water (when more restrictive than PAL); NA = no guideline; federal and provincial data have been combined.

Source: Ontario Ministry of Environment and Energy, 1984.

impact on the aquatic environment. Major developments that will have potentially significant impacts on water resources are subject to the Environmental Impact Assessment process. Industrial and municipal effluent emissions to water are regulated by the *Environmental Protection and Enhancement Act*.

The Northern River Basins Study (NRBS)

The Northern River Basins Study was initiated in 1991 in response to public concern about the rapid pace of forestry developments in the Peace, Athabasca and Slave river basins. The objectives of the study are:

- to provide scientifically sound information for the planning and management of the aquatic environment of the study area;
- to collect and interpret data and develop appropriate models for use in predicting and assessing cumulative impacts of development; and
- to ensure that the purpose, progress and results of all studies are reported regularly to the public.

The NRBS agreement was signed by ministers from the governments of Canada, Alberta and the Northwest Territories. About $11.5 million will be spent over the study term, which runs from fall 1991 to spring 1996.

Water Management Projects

Significant resources have been invested in water management infrastructure in Alberta. These projects provide flood protection, erosion protection, lake level management and water supplies for domestic, municipal, agricultural, industrial, hydropower and recreation purposes throughout the province. The infrastructure includes water level control structures on natural lakes, on-stream and off-stream reservoirs, diversion structures, canals, flood control dykes, erosion control structures and so on. The large infrastructure in southern Alberta provides water for most of the area south and east of Calgary; much of this infrastructure was originally built to support irrigation. Reservoirs were built to store spring runoff for later release in the summer to meet irrigation demands. These structures also serve other purposes including municipal, domestic, industrial, recreational and agricultural and the maintenance of instream needs and recreation.

The locations of 92 major water management projects in the province are shown in Figure 4.14. Of these, 79 are Alberta Environmental Protection projects, including 35 reservoirs, 31 regulated lakes, and 13 water diversions. The remaining 13 are TransAlta Utilities projects, including 11 reservoirs, and a reservoir and water diversion in the Eastern Irrigation District. This total does not include the numerous smaller-scale water management structures operated by Ducks Unlimited, other levels of government, irrigation districts or private citizens and other nonprofit organizations (Figure 4.15).

Monitoring

Monitoring is required to determine the quantity and quality of Alberta's water resources. Through a federal-provincial cost-sharing agreement, over 480 river flow and water level stations are operated throughout the province. In addition, water levels are measured at over 200 lakes throughout Alberta. The province operates a river water quality monitoring network, which includes 13 long-term sites. Alberta Environmental Protection also measures water quality in a variety of lakes throughout the province. These data are used by a variety of agencies for a wide range of purposes including flood forecasting and water management operations.

Water Treatment

Water must be treated to remove any contaminants that may present a risk to the consumer. Contaminants may be physical, chemical or microbiological in nature. Standard water treatment reduces contaminants to the levels outlined in the *Guidelines for Canadian Drinking Water Quality*. The number of water treatment systems, the population they serve and the volume of water treated in 1992 are summarized in Table 4.6. Over the years, the number of Albertans supplied with fully treated water has increased, compared to the number whose drinking water receives only minimal or partial treatment (Table 4.7). Of particular importance is the treatment for microorganisms that can cause diseases. This treatment is necessary for all surface waters and many groundwaters, including water from lakes

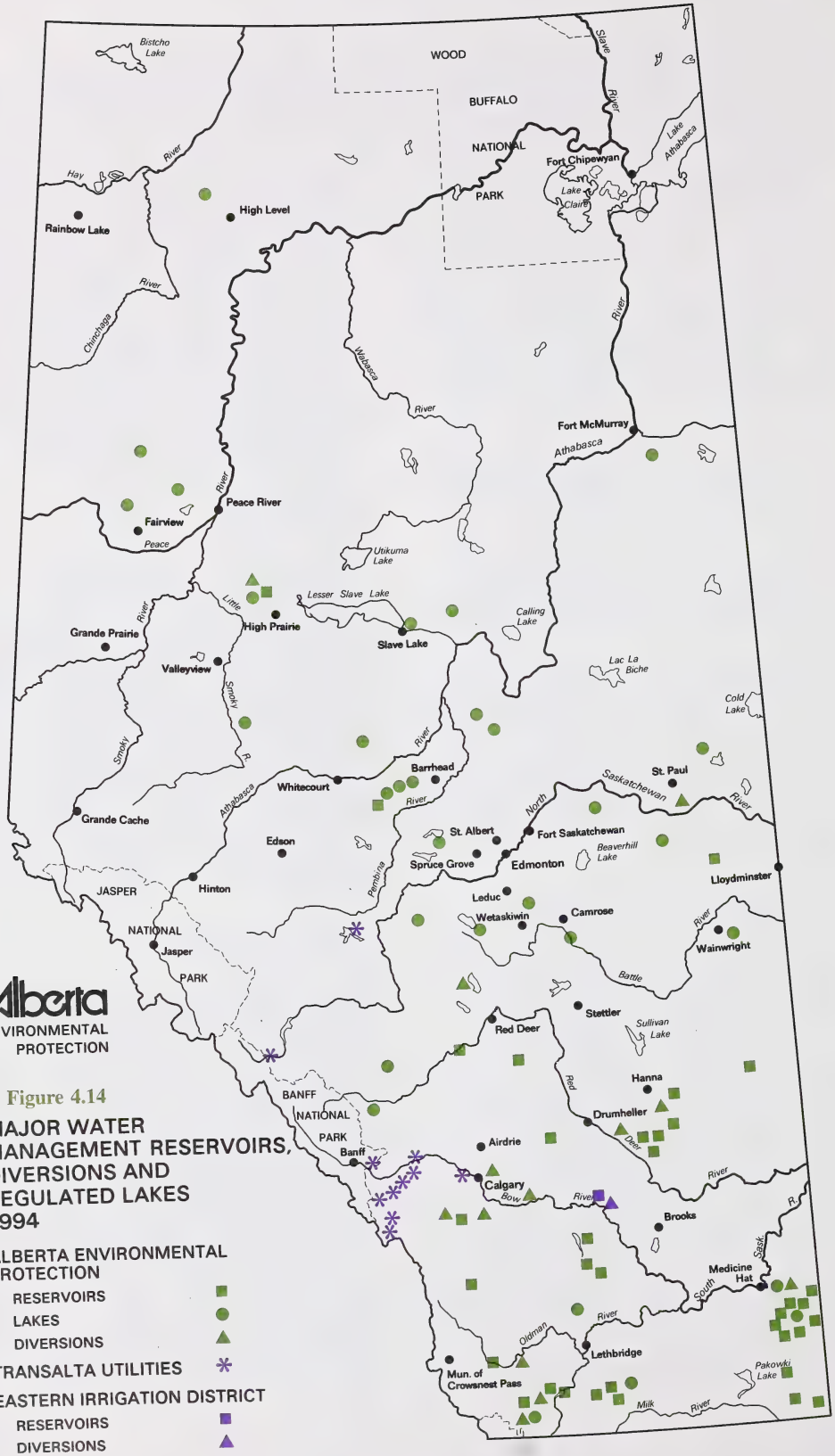


Figure 4.14

MAJOR WATER MANAGEMENT RESERVOIRS, DIVERSIONS AND REGULATED LAKES 1994

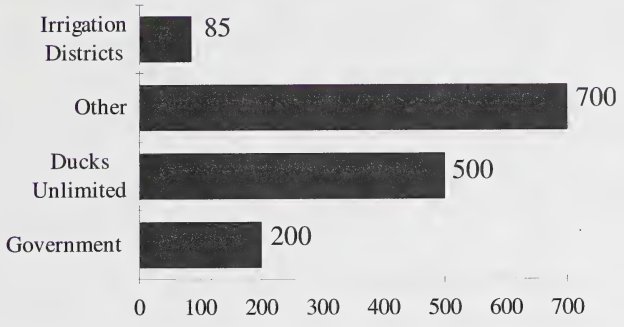


Figure 4.15 Operators of Control Structures.

Source: Water Resources Services, Alberta Environmental Protection.

and rivers that appear pristine and isolated from the influence of human activities (Table 4.8).

Restoration Projects

Pine Lake is an important recreational lake in south-central Alberta, used by about 5000 people on an average summer weekend. Over the past several years, there has been concern among the users about increased algal and weed growth, murky water and dead fish. An investigation was initiated in 1989. A preliminary report produced in 1991 suggested that water quality could be improved by reducing nutrient loading. Alberta Environmental Protection in partnership with a local society has begun a water quality restoration program.

Table 4.6 Summary of Drinking Water Systems in Alberta, 1992.

Source	Number of Systems	Population Served	Flow (m^3/yr)
Groundwater	345	73 686	52 878 280
Surface water	290	1 939 546	424 033 640
Ground and surface water	12	29 717	4 731 860
Total	647	2 042 949	481 643 780

Source: Water Resources Services, Alberta Environmental Protection.

Table 4.7 Summary of Surface Water Supplies in Alberta, 1978 to 1993.

Year	Minimal Treatment		Partial Treatment		Full Treatment	
	Number of Systems	Population Served	Number of Systems	Population Served	Number of Systems	Population Served
1978	28	24 360	28	30 467	81	1 310 717
1983	24	22 436	57	69 627	99	1 484 589
1988	10	8 668	70	83 672	116	1 750 851
1993	4	388	23	9 387	168	1 942 342

Source: Water Resources Services, Alberta Environmental Protection.

Table 4.8 Summary of Bacteriological Samples Analyzed, 1978 to 1993.

Year	Total Number of Samples	Number of Unsatisfactory Samples
1978	14 094	114
1983	21 916	90
1988	33 078	65
1993	34 979	50

Source: Water Resources Services, Alberta Environmental Protection.

KEY POINTS

- Of the water that leaves Alberta through rivers, just under one-half originates within the province.
- Water flow in Alberta rivers varies from year to year. The Peace and Athabasca rivers show the least amount of variability and the Battle and Beaver rivers the greatest.
- Water quality varies with season, year and location. Water quality concerns in Alberta include the effects of discharges from the pulp industry and from urban areas, and levels of disease-causing bacteria, viruses and parasites.
- Variations in lake water quality occur around the province. This variation is a result of differences in soils, climate, vegetation, size of the drainage basin and groundwater entering the lake.
- Groundwater is a source of potable water, containing an estimated 100 million cubic decametres in sand and gravel aquifers alone.
- Southern Alberta has the greatest demand for water, but has only 14 percent of the water supply. Northern Alberta has most of the water supply, but the least demand.
- To meet water use demands, water is withdrawn from Alberta rivers, lakes and groundwater. In 1993, 6 822 382 cubic decametres of water were licensed for withdrawal. Most of the licensed water comes from the Bow, Oldman and North Saskatchewan rivers.
- Growing demands have caused shortages and full allocations of water from some river basins.
- Pulp mills discharge substances like suspended sediments and chlorinated organic compounds (e.g., dioxin). Most (about 99 percent) of the chlorinated organics pose little or no environmental threat. Since 1991, there have been no detectable levels of dioxin in water samples collected by the four Alberta kraft pulp mills.
- Pesticides have been detected in all Alberta river basins. In most cases, the significance of detecting them is not known. Most pesticides have only been detected in a small number of samples. Lindane, alpha BHC, 2,4-D and 2,4,5-T are the pesticides that are most frequently detected.
- There are 92 major water management projects in Alberta.
- Water must be treated to remove contaminants. The number of people supplied with treated water in Alberta has increased compared with the number of those who are not.

FUTURE DIRECTIONS

- The Government of Alberta will continue its review of current water management policy and legislation. Key issues in this review will include:
  - the need for planning;
  - water conservation;
  - the integration of water quality and quantity objectives; and
  - the protection of instream needs.

5.0 LAND

This section of the report discusses provincial land use activities and how these activities impact the land. Province-wide, the demands for land use continue to rise, leading to land allocation conflicts and concerns for the protection of environmental quality. The following subsections discuss forestry, agriculture, mineral extraction, wetlands, protected areas and waste management. The roles of forestry, agriculture and mineral extraction in the provincial economy are indicated in Tables 5.1 and 5.2.

Table 5.1 Employment in the Agriculture, Forestry and Mining Industries, 1994.

Agriculture	77 600
Logging and Forestry	2 500*
Mining	61 300

*This figure includes only those directly involved in the forest industry, and not sawmills, pulp and paper mills, etc. Industries that process timber are considered as part of the manufacturing industry, which employed 94 800 people as of April 1994.

Source: Alberta Economic Development and Tourism, 1994.

Table 5.2 Gross Domestic Product by Industry, 1981 and 1991.

	1981	1991
	(Millions of Dollars)	
Agriculture*	1 830	2 286
Forestry**	53	208
Mining	8 579	11 267

* Includes fishing and trapping
** Includes only logging services incidental to forestry; excludes sawmills, pulp and paper mills, etc. which are included in manufacturing

Source: Alberta Treasury, 1992.

5.1 FORESTED LAND

Alberta's forests occupy two-thirds of the province, with the majority contained within the Green Area. The Green Area is managed for multiple forest resource values, including the following:

- watershed values;
- timber production;
- wildlife habitat;
- aesthetic/landscape values;
- recreation and tourism values; and
- range values.

Society's demands upon these forest resources are continually increasing. The major issue facing forest managers today is how to achieve a balance between maintaining the diversity and productivity of the forest ecosystem with the sustainable development of the forest resource.

Presently, over 20 000 people are employed directly or indirectly in Alberta's forest industry. In 1986, the value of the forest products manufactured in Alberta was $1 billion; this annual value is projected to reach $3 billion by 1995.

A. PRESENT CONDITIONS

Alberta's forests are composed of a variety of commercial tree species (used by the forest industry). White spruce, black spruce, lodgepole pine, jack pine, balsam fir, Douglas-fir and tamarack are the most common conifers. Aspen, balsam poplar and white birch are the most common deciduous species. Inventories of forested lands in Alberta show that forests are relatively young with 70 percent being less than 120 years of age.

The Phase 3 Inventory (Table 5.3) classifies land according to its potential to grow trees and uses three categories. These categories apply solely from the perspective of a commercial timber inventory. All three land categories, listed below, may be highly productive for a range of other resource values.

- Productive: Land that is capable of yielding at least 50 cubic metres per hectare of wood volume within 120 years.

- Potentially Productive: Land where disturbance has removed the tree cover, but which still has the capability to grow trees if reforested.

- Non-Productive: Land that is not capable of meeting the above productive and potentially productive growth timelines.

Phase 3 Inventory indicates that 53 percent of the forested land is productive, 6 percent is potentially productive and 37 percent is non-productive. The remaining 4 percent of the forested land is covered by water.

Pure coniferous stands occupy 47.4 percent of the productive land base. Pure deciduous stands occupy 32.8 percent; mixedwood stands dominated by coniferous trees occupy 10.4 percent; and mixedwood stands dominated by deciduous trees occupy 9.5 percent.

B. STRESSES

Fire

Nearly all of Alberta's forests are of fire origin. Table 5.4 shows that in the last 50 years, fire has burned over 75 percent of Alberta's forest area. Some of this area has been burned more than once. The size, shape, distribution pattern and species composition of tree stands are influenced over time by a combination of climate, landforms and the frequency of fire. Lodgepole pine forests, for example, commonly occur as large, extensive patches as a result of infrequent, severe fires that result in the replacement of the existing tree stands. In contrast, Douglas-fir forests in montane valleys of the Eastern Slopes region occur in smaller, separated patches as a consequence of frequent, low-intensity ground fires that did not kill the mature trees.

Although fire is a natural event in the forests, it is also one of the greatest threats to the province's forest resources. On average, about 1000 forest fires start each year. This fire frequency has resulted in an average annual loss of nearly 22 000 hectares over the past 10 years. Approximately 45 percent of these wildfires are caused by people and are therefore preventable.

Insects and Diseases

Forests in Alberta are threatened by a number of insect pests and diseases. Table 5.5 outlines the

Table 5.3 Phase 3 Forest Inventory Summary by Green Area and White Area Forest.

Volume (1000's cubic metres)*

Green Area Forest	Area (hectares)	White Spruce	Black Spruce	Pine	Balsam Fir	Douglas Fir	Larch	Aspen	Balsam Poplar	White Birch
Athabasca	6 068 172	36 960	10 825	38 419	2 349	0	315	38 780	6 153	2 466
Bow/Crow	1 225 278	26 302	2 444	56 547	3 342	932	9	5 113	1 602	171
Edson	2 341 751	53 418	17 410	142 964	7 053	369	159	28 177	5 885	1 210
Footner Lake	7 709 692	144 241	11 729	16 060	1 411	0	1 027	95 019	11 461	6 608
Grande Prairie	2 132 787	68 951	10 438	71 034	4 725	162	184	80 124	21 723	3 328
Lac La Biche	3 158 115	39 744	10 440	22 867	2 198	2	205	49 256	9 239	2 306
Peace River	3 625 951	83 198	10 549	35 693	2 661	15	365	99 334	22 479	4 828
Rocky/Clearwater	1 646 938	38 516	7 689	86 974	3 056	104	59	20 868	5 122	555
Slave Lake	5 232 509	125 233	20 093	42 957	6 591	77	507	130 953	14 601	2 159
Whitecourt	1 821 567	49 991	20 735	74 058	5 700	148	364	46 788	13 119	3 219
Total	34 962 723	666 559	122 357	587 577	39 089	1 814	3 200	594 412	111 389	26 853

White Area Forest	Area (hectares)	White Spruce	Black Spruce	Pine	Balsam Fir	Douglas Fir	Larch	Aspen	Balsam Poplar	White Birch
Athabasca	1	0	0	0	0	0	0	0	0	0
Bow/Crow	531 303	2 976	284	4 846	223	400	1	1 932	605	73
Edson	106 804	790	219	661	51	1	5	1 775	324	64
Footner Lake	401 171	4 982	195	524	41	0	26	8 449	1 044	576
Grande Prairie	576 915	4 632	368	1 282	83	0	12	13 344	3 497	460
Lac La Biche	365 993	1 291	185	418	100	0	3	2 734	594	158
Peace River	784 809	10 733	580	2 281	202	0	32	23 963	5 686	1 017
Rocky/Clearwater	695 606	2 312	504	1 689	107	0	8	5 180	2 373	137
Slave Lake	679 415	4 536	491	1 471	184	1	15	11 570	1 363	273
Whitecourt	435 512	3 475	852	2 387	264	4	24	6 754	2 367	269
Total	4 576 897	35 730	3 681	15 742	1 257	409	131	75 705	18 039	3 030
TOTAL	**39 539 620**	**702 290**	**126 038**	**603 319**	**40 347**	**2 224**	**3 332**	**670 117**	**129 428**	**29 884**

* Based on a minimum diameter of 15+ centimetres outside bark at stump height to a maximum small end diameter of 11 centimetres (inside bark).

Source: Land and Forest Services, Alberta Environmental Protection.

impacts of significant pests on the province's forests. Of the pests listed, eastern spruce budworm has had the most significant impact. An ongoing study of a biological insecticide for spruce budworm is discussed on page 53.

Industrial Activities

The timber harvesting industry is a major disturbance to forest ecosystems. The potential impacts of timber harvesting operations include habitat loss, loss of biodiversity, and soil compaction and erosion due to roads, logging trucks and the movement of machinery. The mitigation of these potential impacts is a basic principle of current forest management in Alberta.

Another industrial activity that stresses the forests is agriculture, which creates the demand for Green Area lands to be converted to rangeland and

cropland. Oil and gas exploration and development also affects forested lands (see Section 5.3 B for the area of land affected by this activity). Some recreational activities may also have impacts on forested lands; examples include all-terrain vehicle trails, skiing lodges and golf courses. The potential impacts of these activities are the same as listed above for timber harvesting.

Forest Inventory

The forest inventory provides the forest manager with basic data needed for timber management in the province. Most of the forested region of the province has been mapped and inventoried. The forest is a living ecosystem, continuing to change as its components grow and die, so inventories must be continually updated.

The most extensive inventory to date, the Phase 3 Inventory, was initiated in 1970 to provide a more complete and accurate description of the forested regions of the province (Table 5.3). It was completed in 1984 and covers approximately 60 percent of the province, encompassing all of the Green Area, with some overlap into the White Area. Forest inventory map and data base records are kept up-to-date for forest depletions (such as burned areas, timber harvesting and land clearings) and geo-administrative changes (e.g., Green/White Area boundary changes, Forest Management Agreement and Forest Management Unit boundaries).

Phase 3 Inventory data are both stored electronically and mapped (at a 1:15 000 scale). The data are used as a source of information for forest management planning and ground operations.

Alberta Vegetation Inventory

The Alberta Vegetation Inventory (AVI) was jointly developed by Land and Forest Services and Fish and Wildlife Services, both of Alberta Environmental Protection, and Forest Management Agreement (FMA) holders. The AVI is a more detailed inventory than Phase 3 and is currently the minimum inventory specification to be followed by the government and FMA holders.

The significance of AVI is that it provides understorey vegetation composition and structure, in addition to tree cover information. This detailed information provides the forest manager with key wildlife habitat information.

At present, priority regions of the province are being inventoried by the government and FMA holders. Current AVI coverage is mainly in the forested region of the White Area not previously covered by the Phase 3 inventory.

To date about 56 000 square kilometres have been inventoried under AVI. This area includes some overlap with the Phase 3 Inventory.

Table 5.4 Summary of Alberta Fire History, 1920 to 1993.

	Average number of fires/year			Average hectares burned/year			Average fire size (hectares)		
Period	Lightning	Man	Total	Lightning	Man	Total	Lightning	Man	Total
1920-1929	6	573	579	N/A	N/A	91 433	N/A	N/A	158.0
1930-1939	14	340	354	N/A	N/A	170 153	N/A	N/A	480.7
1940-1949	9	265	274	N/A	N/A	230 013	N/A	N/A	839.5
1950-1959	36	197	233	18 918	80 071	98 898	525.5	406.5	424.8
1960-1969	172	342	514	14 564	40 520	55 084	84.5	118.5	107.2
1970-1979	281	439	719	36 833	7 102	43 935	131.3	16.2	61.1
1980-1989	532	535	1 067	238 799	44 755	283 553	448.6	83.7	265.7
1990-1993	631	400	1 031	14 289	2 178	16 467	22.6	5.4	15.9

Source: Land and Forest Services, Alberta Environmental Protection.

Table 5.5 Summary of Major Forest Pest Outbreaks in Alberta, 1988 to 1993.

Type of Pest	1988	1989	1990	1991
Eastern Spruce Budworm	Approximately 61 900 hectares of mature spruce stands were defoliated in mostly the northern part of Alberta.	85 850 hectares of mature spruce stands were defoliated in the same areas as in 1988.	109 150 hectares of mature spruce stands throughout northern Alberta were defoliated.	141 000 hectares of mature spruce stands throughout northern Alberta were defoliated.
Forest Tent Caterpillar	2 766 000 hectares of aspen stands throughout the province had moderate to severe defoliation.	1 179 800 hectares of aspen stands throughout the province had moderate to severe defoliation.	609 272 hectares of aspen stands throughout the province had moderate to severe defoliation.	129 200 hectares of aspen stands throughout the province had moderate to severe defoliation.
Mountain Pine Beetle	Scattered patches of recently killed pine trees throughout Waterton Lakes National Park, Yoho National Park and Kootenay National Park.	More than 600 trees were killed in southwestern Alberta; 20-30 trees were killed in Waterton Lakes National Park.	Small number of attacks throughout southern Alberta, Yoho National Park and Kootney National Park.	Only endemic population levels found in southwestern Alberta.
Jack Pine Budworm	70 hectares of jack pine stands were lightly defoliated.	70 hectares of jack pine stands were lightly defoliated.	Low populations found north of Clyde.	N/A
Dwarf Mistletoe	Some infection in Jasper National Park.	N/A	N/A	N/A
Bruce Spanworm	N/A	Several hectares of moderate to severe aspen defoliation in south and central Alberta.	Approximately 352 350 hectares of aspen defoliated.	Increasing population level found in the Peace River forest.
Spruce Beetle	N/A	Endemic populations found across Alberta.	300-400 spruce trees in the Slave Lake Forest were killed; some spruce in the Peace River Forest were also killed.	N/A
Spruce Needle Rust			Damage found throughout central and northern parts of Alberta.	N/A
Terminal Weevil			Some young stand blocks near Hinton had up to 10 percent infested tress.	N/A
Armillaria Root Rot			Found throughout southwestern and central Alberta.	N/A
Gypsy Moth			N/A	Isolated moth findings on traps placed at four locations in the province.
Pine Needle Cast			N/A	Foliage discoloration of lodgepole pine found extensively throughout the southwest.

Source: Land and Forest Services, Alberta Environmental Protection.

Table 5.5 (continued).

Type of Pest	1992	1993*
Eastern Spruce Budworm	142 150 hectares of mature spruce stands throughout northern Alberta were defoliated.	48 978 hectares of mature spruce stands throughout northern Alberta were defoliated.
Forest Tent Caterpillar	Low populations found throughout Alberta.	N/A
Mountain Pine Beetle	Only endemic population levels found in southwestern Alberta.	Endemic levels found in southwestern Alberta.
Spruce Beetle	Increasing population level found in the Peace River forest (about 1000 hectares).	Population continued to increase in Peace River.
Armillaria Root Rot	Found throughout the province.	N/A

* Other noteworthy pests, found in small amounts throughout the province in 1993 were:

Armillaria Root Rot
Spruce Budworm
Dwarf Mistletoe
Hypoxylon Canker
Forest Tent Caterpillar
Large Aspen Tortrix
Needle Cast
Root Collar Weevil
Spruce Cone Midges
Spruce Cone Rust
Spruce Needle Rust
Terminal Weevil
Western Gall Rust

Sustained Yield Management

Forests in Alberta are managed on a sustained yield basis. Sustained yield means that the volume of timber harvested each year does not exceed the volume grown.

The level of permitted harvest each year is called the annual allowable cut (AAC) and is determined for both coniferous and deciduous timber. Figure 5.1 summarizes the AAC for the province. The timber supply is allocated for harvesting using different categories as described in the figure.

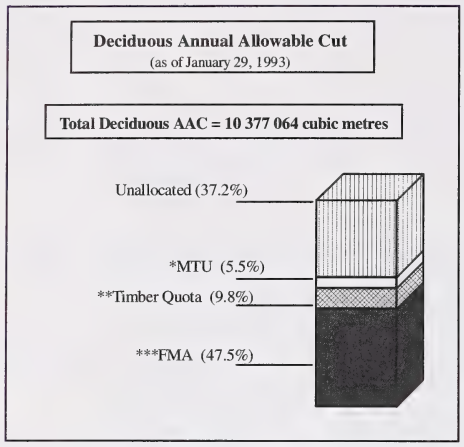
The AAC is based on what the forest will grow, not on the size of the existing forest industry. It is calculated using the net forested land base that is available for timber production. Based on the January 23, 1994 AAC summary, the provincial AAC was approximately 24.7 million cubic metres, of which 58 percent was coniferous and 42 percent was deciduous. During 1991-92, only 68 percent of the coniferous AAC, and 22 percent of the deciduous AAC was actually harvested. At present, less than 1 percent of the productive Green Area is being harvested annually.

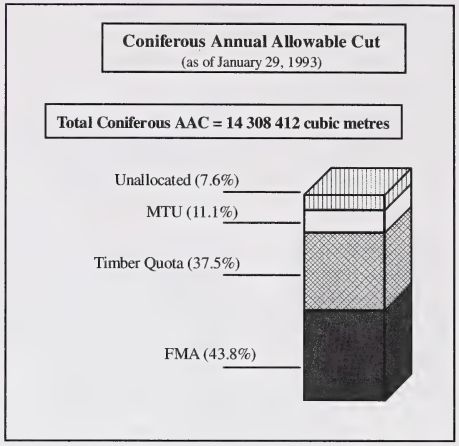
The AAC information is one of the components included in a forest management plan. These plans describe the allocation and harvest schedule for an administrative area of forest termed a Forest Management Unit (FMU). Each plan sets out long term strategies for the overall management of an area. The public can provide input during the development of these plans.

Harvesting Techniques

Much of Alberta's forest has even-aged stands resulting from wildfire. The best way to harvest these stands is by an alternate patch system of clearcut harvesting, where isolated blocks of limited size are created. Because of the regeneration requirements of many of Alberta's tree species, an attempt is made to remove all the merchantable wood within small blocks with irregular boundaries. The average cutblock size in Alberta is less than 20 hectares.

Block size and shape are determined by such factors as topography, timber condition, fish and wildlife habitat, aesthetics, and water and soil conservation. Small block size promotes natural seeding from adjacent areas and encourages use of blocks by some animals such as elk and moose.





***Miscellaneous Timber Use (MTU)**

This describes a portion of the AAC that is reserved for local community use and timber operators with low volume requirements. The MTUs are issued for short periods of time, usually one to five years, using a permit system. Types of permits include Coniferous Timber Permit, Deciduous Timber Permit and Local Timber Permit.

****Timber Quotas**

There are two forms of quotas: a Coniferous Timber Quota and a Deciduous Timber Allocation (DTA). The quota system entitles a registered Quota/DTA certificate holder to a proportion of the AAC. A Quota/DTA certificate is issued for a 20-year period. Alberta has 50 companies holding 146 quota certificates and 15 DTA certificates.

*****Forest Management Agreement (FMA)**

A Forest Management Agreement is a negotiated and legislated agreement between the government and a company to establish, grow and harvest timber on a sustained yield basis. Alberta has 11 FMAs.

Figure 5.1 Annual Allowable Cut Summary for Alberta.

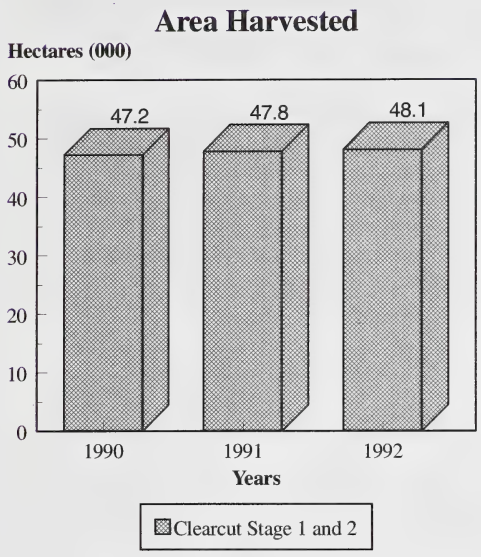
Source: Land and Forest Services, Alberta Environmental Protection.

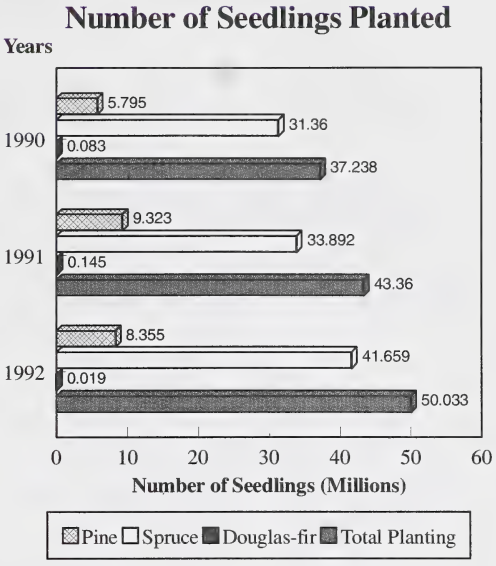
Irregularly shaped blocks increase the edge effect, which benefits some wildlife, and improves aesthetics by more closely simulating natural openings.

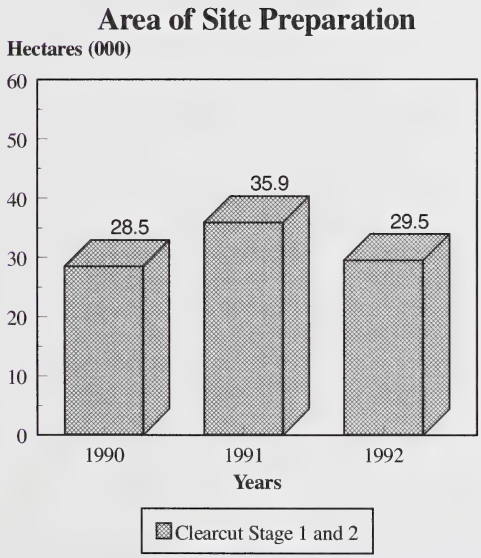
Companies occasionally use selective harvesting to protect unique areas or maintain certain kinds of vegetation. Selective harvest is the removal of certain tree species or sizes of trees only, leaving some vegetation behind. This method is used in stands of uneven-aged trees in order to protect the younger understorey growth. Recent trials have been conducted, protecting young seedlings and saplings and harvesting all the mature trees. Harvest statistics for Alberta are shown in Figure 5.2.

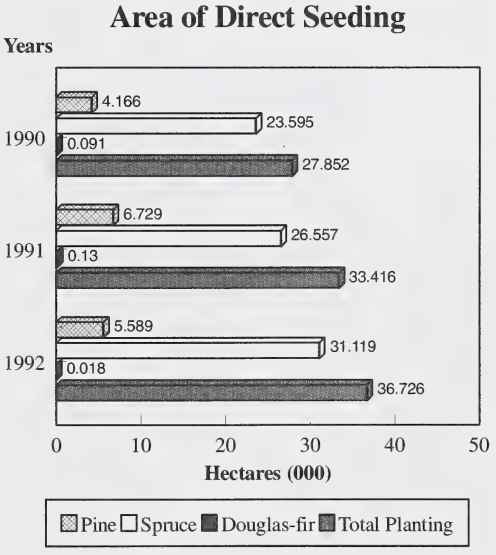
Ground Rules

Alberta has developed Timber Harvest Planning and Operating Ground Rules, which outline the practices that must be followed when harvesting timber from Alberta's forested lands. They indicate the presently expected standard of conduct in harvesting timber, specify the level of planning required toward the attainment of that goal, identify and accommodate multiple use concerns and prescribe the minimum standards for soil and watershed conservation. Ground rules provide direction in regard to block sizes, visual assessments, utilization standards, reforestation, wildlife management, watercourse management, road construction and cleanup requirements.









Figures 5.2 Silvicultural Statistics for Alberta-wide Forestry.

Source: Land and Forest Services, Alberta Environmental Protection.

Ground rules are also negotiated with each FMA holder and are tailored to issues specific to each company's operating area. All companies must work under these planning and harvesting guidelines, which are updated every two to five years to keep current with research, technology and conditions.

The ground rules along with legislation, ensure that timber companies carry out continuous planning. FMA holders are required to prepare plans, such as a Preliminary Forest Management Plan, a Detailed Forest Management Plan and a Public Involvement Plan, which reflect integrated resource management. FMA holders as well as quota holders also prepare General Development Plans, Annual Operating Plans and Reforestation Plans, which reflect operational and site-specific concerns. These plans are reviewed by government forestry and wildlife experts to ensure that the ground rules are being followed.

Herbicide Use

Although herbicides are not commonly used for forestry applications in Alberta, the application of herbicides is one method of ensuring proper conifer regeneration after harvest. Conifer regeneration is usually hampered by competition with heavy grass cover or excessive deciduous cover. Maintaining the coniferous component of tree stands is important, in order to ensure this portion of the forest industry in Alberta is sustainable. The proper use of herbicides reduces the competition for a period of time, allowing coniferous seedlings a better chance for good early growth.

All herbicide applications for forestry use are reviewed by several government agencies. These agencies are responsible for ensuring that the proposed treatments will not pose a threat to human health or the quality of the environment. Public meetings are held for any proposed herbicide application project greater than 20 hectares. The public is also notified about smaller projects, usually through local newspapers.

Reforestation

An important component of sustained yield management is a reforestation policy. To ensure future wood volumes, seedlings must be re-established promptly on harvested areas. The growth of the new forests must be monitored, and intensive management strategies employed to ensure that the desired level of tree growth is achieved.

Techniques for reforesting an area, such as the careful spacing of trees and proper maintenance, do not just replace the harvested forest. These techniques also improve the land's suitability for forestry and can create more open forests that favour some wildlife and some watershed components. Reforestation statistics for Alberta are included in Table 5.6.

C. ACTIONS

Fire Protection

On average, there are 1000 fires started in the Forest Protection Area of the province each year (the Forest Protection Area includes the Green Area and small communities that border forested lands). For public safety and economic reasons, Alberta has established one of the most advanced forest protection agencies in the country. Alberta's Wildfire Suppression Program consists of four key elements:

- prevention: The fire that never starts is the easiest to combat. Given that 45 percent of wildfires are caused by human activities, education is an essential part of fire prevention. Land and Forest Services of Alberta Environmental Protection educates the public about wildfire prevention through advertising, visits to schools and mill sites, and discussions with industry workers and the general public. Another method of prevention is to reduce wildfire risks through ecological practices. Such practices include the layout of forest cutblocks, and the placement of roads. Enforcement is the most direct method of prevention. Enforcement includes limiting access and activities through a fire ban.

- detection: Alberta's fire detection network consists of 132 lookout sites located strategically throughout the forested area of the province. It also includes an electronic lightning detection system that senses lightning strikes (which are the major causes of forest fires). Aircraft patrols and infrared scanning of the ground are used to cover blind spots in the detection system. There

Table 5.6 Status of Reforestation in Alberta to April 30, 1993.

I. Areas Harvested Before March 1, 1991

Age Class of Tree Stands (years since harvest)	**Status**
Older than 10 years	97 percent satisfactorily restocked
	Less than 1 percent still require treatment
	2.9 percent are awaiting regeneration surveys
8-10 years old	80.4 percent satisfactorily restocked
3-7 years old	7 percent have been considered as leave-for-natural
0-2 years old	12.9 percent waiting for post-harvest treatments

II. Areas Harvested on or After March 1, 1991

Age Class of Tree Stands (years since harvest)	**Status**
0-2 years old	33.7 percent waiting for post-harvest treatments

Source: Land and Forest Services, Alberta Environmental Protection.

is also the 427-FIRE hotline for public reports of wildfire.

- presuppression: This element involves the deployment of firefighting resources to those areas where fire starts are expected. The firefighting resources include airtanker and helitack groups, firefighting crews and warehouses for firefighting equipment. Presuppression has played a significant role in reducing the losses of forest lands to wildfire. From 1973 to 1982, fires burned 2.95 million hectares of forest lands. With the presuppression system, this loss was reduced to 194 000 hectares from 1983 to 1992.

- suppression: Fire suppression refers to combating wildfires with firefighters, aircraft, trucks, bulldozers and small equipment.

During the past five years, annual wildfire suppression costs have averaged $43.7 million.

Spruce Budworm

The spruce budworm is a significant insect pest in Alberta's forests. This insect feeds on the white spruce stands that make up much of Alberta's northern boreal forest. A study researching the effects of a biological insecticide on spruce budworm is showing promise. This study is investigating the potential of the bacterial agent *Bacillus thuringiensis* (B.t.) in controlling spruce budworm. The study was started in 1992 and is sponsored by the Canada-Alberta Partnership Agreement in Forestry, Alberta Environmental Protection and Canada's Green Plan.

The study monitors treated stands that have been sprayed with B.t. and untreated stands, then it compares the results. In untreated areas, up to 1 cubic metre per year of potential tree growth is lost to the spruce budworm. In treated stands, however, spruce budworm populations have been effectively suppressed.

Although B.t. is considered to be a very benign insecticide, a study by the Canadian Wildlife Service is under way in Saskatchewan to examine the impacts of B.t. treatments on species that feed on insects, such as songbirds.

Forest Conservation Strategy

Alberta's forests are important resources and must be managed wisely. The demands on our forests are increasing, and a new strategy for conserving and managing forest resources is required. To address this need, the Alberta government is facilitating the development of the Alberta Forest Conservation Strategy (AFCS). The AFCS goal is as follows:

To maintain and enhance the long-term health of our forest ecosystems, for the benefit of all living things locally, provincially, nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations.

Participants from the forest industry and the environmental, aboriginal, Metis and academic communities are developing the strategy, with the Alberta government serving an advisory and facilitation role. A Stakeholder Advisory Group, made up of representatives from over 60 organizations, provides overall direction for the AFCS. A Steering Committee manages the development of the AFCS, based on direction from the Stakeholder Advisory Group (which also provides the Steering Committee's membership).

Input from Albertans is being obtained largely through two sets of working groups. The Strategic Issues Working Groups focus on provincial-scale issues that require in-depth analysis. The Community Working Groups work on resolving issues that are important at the regional or community level. These groups will submit reports to the Steering Committee and Stakeholder Advisory Group. Members of the public are also providing input through community workshops, conferences and written submissions.

The AFCS objectives will be to set the goals and establish the principles for the future use, protection and enhancement of our forests. The AFCS will develop the procedures for meeting these goals and will set the course for forest management and conservation well into the next century. Legislation, such as the *Forests Act,* will be extensively reviewed during the Strategy's development and recommendations will be made to amend the Act and/or to draft new forest legislation. Other, related legislation will also be reviewed during the process.

The AFCS will not be an end in itself. It will be a beginning. The Strategy will be dynamic and flexible, and will change to meet the needs of Alberta's forest in the future. More than anything, it will become a process, a way of communicating and of doing business.

The Strategy will mean some fundamental changes in the way the province's forest industry operates and in the way government makes decisions. Facing these changes will require courage and commitment.

KEY POINTS

- According to the Phase 3 forest inventory (the most extensive inventory to date), 53 percent of the forested land in Alberta is productive, 6 percent is potentially productive and 37 percent is non-productive. The three most numerous tree species are white spruce, aspen and pine.

- Fire is a significant threat to forests in Alberta, resulting in an average annual loss of about 22 000 hectares over the past 10 years. Alberta's Wildfire Suppression Program has, however, helped to reduce these losses.

- A number of insect pests and diseases threaten forested lands in the province. Eastern spruce budworm has had the most significant impact. A study is currently investigating the effectiveness of a bacterial agent for controlling this pest.

- Timber harvesting is a major disturbance to forest ecosystems. To mitigate the impacts of this activity, Alberta forests are managed on a sustained yield basis, which sets yearly levels of permitted timber harvest (the annual allowable cut, or AAC). From 1991 to 1992, 68 percent of the coniferous AAC and 22 percent of the deciduous AAC was harvested.

- Other activities that stress the forests in Alberta include agriculture, oil and gas exploration and recreational activities.

- There are ground rules in Alberta that outline how timber is to be harvested from public land. Timber companies prepare plans, which are reviewed by government to ensure that the ground rules are followed.

- Reforestation is an important part of the sustained yield management of Alberta's forests. Of those areas harvested before 1991, the majority (97 percent) have been satisfactorily restocked (the percentage of the area meeting the reforestation standard of the total area expected to meet the standard in that year).

- The Alberta Forest Conservation Strategy is currently being developed by participants from the forest industry and the environmental, aboriginal, Metis and academic communities. The Alberta Government is serving as an advisor and facilitator. The goal of the strategy is wise, long-term management of our forest ecosystems.

FUTURE DIRECTIONS

- The Alberta Vegetation Inventory, which will provide a more complete picture of the province's forested lands, will be completed.

- Work will continue on the Alberta Forest Conservation Strategy, which will provide guidance for managing the long-term health of forest ecosystems.

5.2 AGRICULTURAL LAND

Agricultural land, which includes both range and cultivated lands, covers about 21 million hectares or one-third of the provincial land base. It includes both privately and publicly owned lands within the settled regions of south, central and northwestern Alberta. Alberta has one of the country's most diverse and productive agricultural economies and accounts for 21 percent of Canada's primary agricultural production. Total annual farm income of just over $4.5 billion is almost evenly divided between the crop and livestock sectors of the industry.

In terms of primary production, Alberta produces two-thirds of Canada's cattle, one-quarter of the wheat, one-third of the canola, and over half of the country's barley and oats. In 1992, the latest year for which estimates are available, 63 percent of primary production moved out of the province into export markets. Value-added products account for 44 percent of these export shipments. Alberta's three biggest customers are the United States, Japan and China.

A. PRESENT CONDITIONS

Since 1905, Alberta has been an important agricultural area. As a result of federal and provincial homestead policies during the first 30 years of Alberta's history, the number of farms grew rapidly, reaching a high of 93 000 in 1941. There are now approximately 57 000 farms in the province. The average farm size has doubled and the amount of land under annual cultivation has increased significantly since the 1940s. Human settlement, accompanied by an expanding and intensified agricultural industry, has had a significant effect on the rural landscape.

Because many farmers are close to nature and depend on the soil and water resources for their livelihood, they see themselves as environmentalists. There are, however, some farming practices that have potential for stressing the environment (Table 5.7).

Given the export nature of the agricultural industry, the opportunities for increased trade under the General Agreement on Tariffs and Trade and the North American Free Trade Agreement, further intensification within the industry is likely. Developing world markets for red meat and Alberta's reputation for high-quality cattle and hogs may result in a significant increase in the number of livestock on Alberta farms and ranches. The trend toward more cattle should have an overall positive effect on the environment as more land is returned to forages, helping to reduce the risk of soil erosion and providing more habitat for wildlife. The concern is with the potential for problems related to manure management. Coupled with the increasing importance of value-added agri-food processing to the Alberta economy and a resultant increase in waste products, the future concerns about agriculture's impact on the environment are likely to relate to the livestock and processing sectors.

B. STRESSES

Excess Tillage and Summerfallow

Excess tillage and summerfallow, the practice of not cropping a field for a year to combat weeds and increase soil nitrogen and moisture levels, have been principal causes of many of agriculture's impacts on the environment. These practices contribute to wind and water erosion, salinization and loss of soil organic matter. They also increase the potential for pesticides and fertilizers to contaminate surface and groundwater.

Wind erosion affects between 400 000 and 600 000 hectares of farmland in Alberta annually. Similarly, more than 600 000 hectares of farmland are at risk of water erosion each year. Salinity is estimated to occur on close to 650 000 hectares of farmland, reducing crop yields by an average of 25 percent.

Farmers in the more arid regions of the province continue to summerfallow because soil moisture at seeding time is often insufficient to germinate a crop. In other areas, summerfallow is used as a means of combatting persistent weeds. Most farmers are now maintaining more crop residue on the soil to minimize the risk of erosion. Others are leaving crop residue (stubble) standing and controlling annual weeds through chem-fallowing (fallowing through the use of chemicals rather than mechanical tilling of soil). Standing stubble serves several purposes as it prevents erosion, increases soil moisture through snow trapping and provides some habitat for wildlife. Herbicides that are registered for chem-fallowing pose little risk to the environment, when they are applied at the recommended rates and according to instructions.

Table 5.7 Potential Impacts of Agricultural Activities on the Environment.

Agricultural Practices	Potential Impact
Excess tillage and summerfallow	⊛ wind and water erosion ⊛ loss of organic matter ⊛ dryland salinity
Agricultural land expansion	⊛ wind and water erosion ⊛ loss of organic matter ⊛ loss of habitat ⊛ loss of biodiversity
Use of pesticides	⊛ water contamination ⊛ human health ⊛ pesticide drift and other off-target damage
Use of fertilizers	⊛ increased soil acidity ⊛ water contamination ⊛ soil microbe population shifts
Grazing land management	⊛ erosion ⊛ habitat reduction ⊛ riparian degradation ⊛ loss of biodiversity
Manure management	⊛ water contamination ⊛ human health ⊛ nuisance odours
Irrigation	⊛ salinity ⊛ inefficient use of water

Source: Alberta Agriculture, Food and Rural Development.

In the last three decades there has been a gradual shift to minimum and zero tillage (no-till) farming systems. This shift has occurred as farmers use new technology and bigger equipment in an effort to reduce costs, labour requirements and the potential for erosion.

The government, in cooperation with producer-run applied research associations and private sector research and extension, has helped reduce the amount of summerfallow and related problems of erosion, salinity and organic matter loss. Summerfallow as a percentage of cropland has dropped from between 40 to 50 percent in the 1950s and early 1960s to its present level of less than 20 percent (Figure 5.3). There are now approximately 1.8 million hectares of summerfallow in Alberta.

The government has also been working with landowners and producer organizations to address salinity problems. Alberta Agriculture, Food and Rural Development conducts salinity investigation and mapping to determine the extent and location of salinity and identify site-specific causes and methods of control.

Agricultural Land Expansion

Agriculture was one of the first major industries in Alberta. Farm and ranch land was developed by breaking native range and clearing forests. Most of the original land clearing was done to produce food at a subsistence level for the early settlers. As technology improved, bigger farm machinery was used to increase farming efficiency. This further contributed to the loss of natural areas, especially wetlands. The need for food also contributed to the cultivation of more marginal, degradation-prone lands and the loss of wildlife habitat and biodiversity.

Alberta has approximately 11 million hectares of prime land for cultivation (Canada Land Inventory Class 1 to 3 lands) and, according to the 1991 Statistics Canada, there are now approximately 11 million hectares of improved farmland in annual crop production (Figures 5.4, 5.5). Nearly all of the land in Alberta that is suitable for annual production is now under cultivation and opportunities for expansion are limited.

The majority of additions to the agricultural land base have come from dispositions of public land leading to sale. However, between 1986 and 1990, public land dispositions dropped from over 8000 hectares to less than 800 hectares per year. As a result of this decrease, there was an annual net loss in the agricultural land base of approximately 8000 hectares between 1986 and 1990, the last year for which data is available.

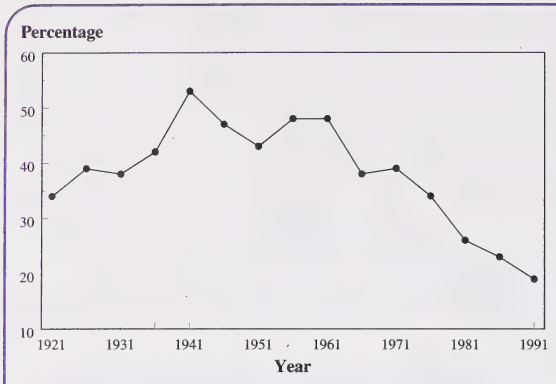


Figure 5.3 Summerfallow As a Percentage of Total Crop Land, 1921 to 1991.

Source: Alberta Agriculture, Food and Rural Development.

In 1989, the federal government established a Permanent Cover Program in cooperation with the province. The government recognized that some land is too environmentally sensitive for annual crop production and should be planted to grass or trees. Over 144 000 hectares of environmentally sensitive farmland was returned to permanent cover while this program was in operation.

Use of Pesticides

The term pesticides includes herbicides, insecticides, fungicides and vertebrate toxicants. These products are used to prevent or control weeds, insects, diseases and vertebrate pests. Pesticides have helped Alberta farmers produce an abundant supply of reasonably priced food products; however, if used improperly, they can become a stress on the environment and a source of health problems (see Section 4.0B).

Most farmers are careful not to over-apply pesticides because they are expensive. However, abuses do occur from time to time due to misunderstanding or label contradictions.

In western Canada, herbicides are the most widely used pesticides. They are generally less toxic than insecticides. Table 5.8 illustrates how the types of insecticides that are used in Alberta has changed over time, primarily in response to concerns about the environment. In the late 1950s and throughout the 1960s, insecticides consisted primarily of organochlorine compounds such as DDT, dieldrin, endrin, aldrin and heptachlor. The toxicity of these insecticides varied from high to low but they all had the property of remaining in the environment and accumulating in the food chain. At the time, risks were unknown since residue and environmental toxicology were emerging disciplines and residue analysis was relatively primitive.

Organochlorines are no longer in common use. Similarly, mercurial fungicides are no longer used because of their toxicity and residual accumulation. Synthetic pyrethroids, such as deltamethrin and permethrin are now commonly used for insect control. These products have lower acute and chronic toxicities and a short residual life. Other carbonate and organo-phosphate insecticides that have high acute toxicities are used but their residual life is short. The ideal low toxicity, non-residual insecticide that controls all insects on all crops is still not available.

Government and the private sector are cooperating on research, product development and management practices to minimize the impact of pesticides on the environment and human health. The pesticide registration system in Canada is one of the most stringent in the world.

Biological (non-chemical) control of weeds, insects and diseases is increasing. In Canada, examples of biological weed control initiatives include the development and use of BIOMAL, a fungus that

Table 5.8 Changes in Insecticides Used From 1960 to 1990.

1960s	1990s
Organochlorine Compounds:	**Synthetic Pyrethroids:**
DDT	deltamethrin
dieldrin	permethrin
endrin	
aldrin	
heptachlor	

Source: Alberta Agriculture, Food and Rural Development.

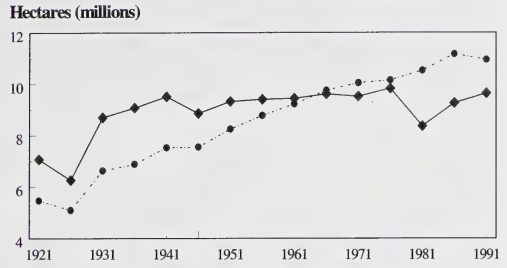


Figure 5.4 Number of Improved and Unimproved Hectares, 1921 to 1991.

Note: Improved includes tame hay, horticulture and summerfallow.

Source: Alberta Agriculture, Food and Rural Development.

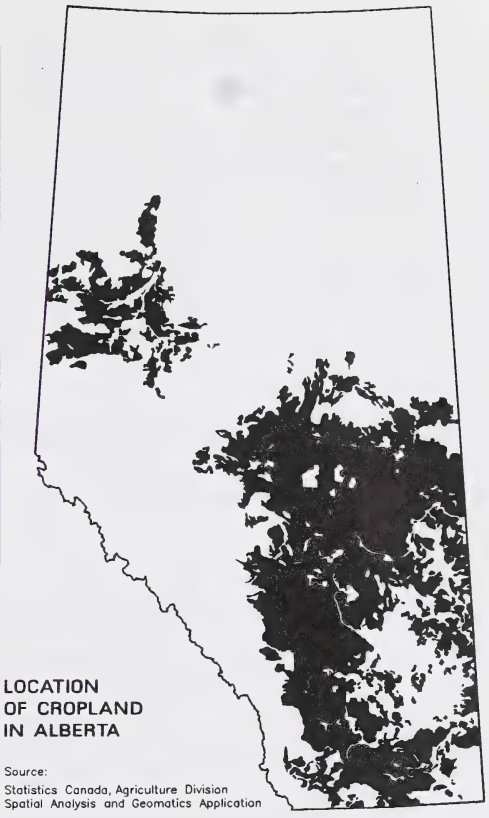


Figure 5.5 Location of Cropland in Alberta.

controls roundleaf mallow, the release of beetles that reduce infestation of leafy spurge, and the use of sheep to control weeds in reforested areas. The use of microbials and parasites for insect control have been long-standing practices but they are limited to only a few insects.

An extensive multi-agency research project is currently in progress to evaluate the use of grass carp, as a biological control of aquatic vegetation in irrigation canals and farm reservoirs.

In 1990, Alberta Agriculture, Food and Rural Development established a Farmer Pesticide Certificate Course in association with Olds College. The purpose of this course is to teach farmers how to prevent unnecessary exposure to themselves and the environment. To date, 3100 farmers have voluntarily enrolled in the course.

Recent research emphasizing ecological approaches to the management of weeds, insects and crop diseases is proving beneficial in reducing total reliance on chemical pesticides. An integrated pest management strategy involving chemical, cultural, biological and mechanical methods is a major component of the sustainability in agriculture.

Use of Fertilizers

Fertilizers are used to replace nutrients that are taken out of the soil by growing crops. They have played a major role in maintaining production efficiency and sustaining Alberta farmlands. Because of inorganic fertilizers and other modern farm technology, agriculture has been able to reduce its need to use environmentally sensitive lands. It is estimated that if we still relied on 1950s technology, the current level of farm production would require more than twice the current land base.

When farms were smaller and more diversified, organic fertilizer in the form of livestock and poultry manure provided most of the nitrogen, phosphorus and potassium for crop production. Now, however, the majority of farmers rely on inorganic fertilizers to supply their crops' nutrient requirements.

Although both organic and inorganic fertilizers are beneficial in producing and maintaining high crop yields, they can be a source of nutrients that leach into the groundwater or run off into surface water if improperly applied. Fertilizers can also contribute to soil acidification, although most acidity is the result of natural processes. Approximately 13 percent of all the improved farmland in Alberta is acidic, with the amount ranging from 5 percent in the southeast to 30 percent in the Peace River region. In total, there are over 400 000 hectares of strongly acid and 1.8 million hectares of moderately acid soils farmed in Alberta. Soil testing helps to minimize the risk of over-applying fertilizer, a practice that would be expensive for farmers and hard on the environment. In the last 30 years, there has been a dramatic increase in the number of farmers who soil test for plant-available nutrients, allowing them to match fertilizer use to crop needs.

A recent analysis of the Alberta Farm Fertilizer Price Protection Plan data base indicates that the majority of fertilizer application rates are within recommended levels. Excessive application rates are rare.

Manure Management

As a result of increasing national and international market opportunities, provincial livestock and poultry operations are growing in both size and number. Larger, more intensive operations have increased concerns about manure handling. Although most livestock and poultry producers do a good job of managing manure, problems can occur near large, intensive livestock or poultry facilities if manure application rates are too high. Excess nutrients can leach into the groundwater or run off into surface water bodies.

When manure is spread on frozen soil or on steep slopes that drain toward surface water, or when cattle are wintered or fed along watercourses, there is also potential for water contamination. Poor handling of manure can also result in odours and flies, which become a nuisance to neighbours.

A federal-provincial water quality committee is currently addressing water quality impacts from feedlot runoff, manure spreading and overwintering livestock feeding sites. It has identified areas of the province where manure management issues are most significant and is working with the beef industry to research better nutrient management practices. The government is also working with the livestock and poultry industry to develop a code of commonly accepted manure management practices and ways to minimize environmental impacts from manure.

Grazing Land Management

As Alberta beef cattle numbers increase to meet market opportunities, the need to properly manage the grassland resource also increases. Poor management practices place both native range and tame pastures at risk for loss of productivity, increased soil degradation and loss of biodiversity.

Streambanks and water quality can also be impacted if livestock are allowed free access to rivers and creeks. This access can result in increased bacteria levels and turbidity, which affect water quality for downstream users and fish habitat.

Drought, overstocking and insufficient pasture rotation can all lead to overgrazing. When pastures are overgrazed for extended periods, desirable species of vegetation are replaced with less desirable, weedy species. In the last few years, however, range condition in Alberta has been improving. Several factors have been contributing to this improvement: better moisture conditions, greater awareness of the value of sustainable range management, increased public scrutiny of rangelands and greater cooperation between ranchers, cattlemens' organizations, the government and other users of grazing lands.

Although there is no overall provincial system to monitor and inventory range condition, both Alberta Environmental Protection and Alberta Agriculture, Food and Rural Development conduct range surveys and grazing lease evaluations on public land. Staff work with leaseholders to develop effective grazing strategies to maintain good condition range or to improve range that has been overused. This reduces the potential for erosion and enhances wildlife habitat.

In 1993, an agreement was reached between cattlemen, Trout Unlimited and the government to cooperate on a pilot project aimed at improving the management of riparian areas for the benefit of all stakeholders. More emphasis is now being placed on protecting river valleys and other critical overwintering areas for wildlife, through preventing

overgrazing by domestic livestock. A number of forage associations have also formed across the province and are cost-sharing research and demonstration projects on forage production and grassland management.

Irrigation

Irrigation has provided a big boost to the provincial economy. Although only 4.5 percent of the province's cropland base is under irrigation, it generates 15 to 20 percent of our agricultural production. Nearly all of the irrigated land is located in southern Alberta where it supports an extensive agricultural processing industry and provides an assured water supply to many communities in the region.

Most of the environmental concerns about irrigation are with increased soil salinity and inefficient water use. Irrigation salinity results primarily through seepage from unlined canals. A 1991 survey of irrigated lands in Alberta found that 12.4 percent of the area was affected by salinity related to irrigation and 13.5 percent was affected by dryland salinity.

Efforts to mitigate salinization and improve water use efficiency have centered around seepage control measures such as canal lining, replacement of open canals with closed pipelines, drain installation and the relocation and straightening of canals. The majority of this work has been carried out through the Irrigation Rehabilitation and Expansion Program. Shallow subsurface drain tubing is also being used to control excess water and allow reclamation to occur.

By addressing the problems of irrigation salinity and inefficient water use, some wetlands that had resulted from leaking canals have been lost. The irrigation districts are now working with wildlife agencies, such as Ducks Unlimited, to allocate water for wetland habitat development.

As a result of canal rehabilitation, subsurface drainage and improved water management, salinity and waterlogging appears to be decreasing within the irrigation districts. Between 1972 and 1990, saline soil within a number of irrigation districts decreased by 10 to 15 percent. Reduced seepage and better on-farm water management has also helped to increase water-use efficiency.

C. ACTIONS

Over the last 10 to 15 years, government and the private sector have increased their cooperation in responding to concerns about agriculture and the environment. Public awareness and public pressures have had a positive influence on actions being taken.

As part of the federal government's Green Plan, federal and provincial agriculture ministries are now on their third consecutive, multi-year agreement to address environmental concerns. Several of the programs under these agreements have been cost-shared with industry. The current agreement provides a framework for addressing a broader range of issues than in the past. This agreement and other major cooperative initiatives are discussed below.

Agreement to Promote Environmentally Sustainable Agriculture

The $44 million Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement was signed in November 1992. This cost-shared, five-year agreement establishes a framework for addressing a broad range of environmental concerns within agriculture. The major concerns being addressed are soil degradation, surface and groundwater quality, water quantity, pollution and waste management, land conservation and wildlife habitat. To a lesser extent, air quality, energy consumption and the preservation of genetic resource material are also being addressed.

Programming under the CAESA agreement is based on priorities that were established during public consultations. The agreement provides funding and other support for research and extension related to the adoption of more environmentally friendly primary production and processing practices. It also funds the monitoring of impacts from agriculture on soil and water quality, the development of an automated soil information system and information gathering on groundwater supplies. Funding is also provided to research better ways of handling wastes generated from agricultural processing. Many of the actions reported in the Stresses section (5.2B) have received funding through CAESA.

Development of an Intensive Livestock Management Action Plan

Intensive livestock and poultry operations are a potential source of nuisance, environmental and health problems because of their associated odours, flies and manure. In 1992, a joint industry-government committee was formed to address problems associated with intensive livestock operations. The committee is developing a waste management code of practice, a voluntary development-permitting process and a proposal for an Agricultural Practices Review Board. The purpose is to provide a consistent, objective means of approving new intensive operations and to help resolve conflicts involving existing farm operations. This initiative is timely, since the number of conflicts is expected to increase as farming operations become larger and more intensive and as rural residential developments continue to move into farming areas.

Development of Environmental Indicators for Agriculture

Since 1993, Alberta Agriculture, Food and Rural Development has been contributing to the federal government's initiative in developing environmental indicators for agriculture. These indicators will be used in future state of the environment reports to monitor agriculture's effects on the environment.

Agriculture and Agri Food Canada, in cooperation with provincial agencies, has established a national network of benchmark sites to monitor change in soil quality and to develop environmental degradation indicators. Four of these sites are located in Alberta. On each site, a cropping system that is typical for that area is being monitored. The project provides another means of evaluating the sustainability of current farming systems in Alberta.

Cooperation Between Agriculture and Wildlife

Since the mid-1980s, Alberta Agriculture, Food and Rural Development has been working closely with wildlife resource managers from the public and the private sector on a number of projects. Two of the most significant examples have been the drafting of a wetlands management policy for the province and development of provincial programs under the North American Waterfowl Management Plan (see Section 5.4C).

The department has also been cooperating with wildlife agencies and other departments in reviewing government policies and programs that conflict with wildlife management objectives. For example, Alberta Environmental Protection, through Fish and Wildlife Services, has been working with Alberta Agriculture, Food and Rural Development and ranchers to demonstrate how fencing off waterbodies and providing off-stream water sources for livestock can benefit all stakeholders. In addition, provincial and federal environment and agriculture ministries and private sector wildlife organizations are working together to address problems and concerns with wildlife damage to crops and livestock.

KEY POINTS

- Agricultural land covers about 21 million hectares or one-third of the provincial land base.
- Approximately 4 percent of the cultivated landbase is under irrigation; irrigation farms generate 16 percent of the province's agricultural production.
- Nearly all of Alberta's arable land is now under cultivation and opportunities for expansion are minimal.
- More than 600 000 hectares of farmland are at risk of water erosion each year.
- Salinity occurs on an estimated 647 000 hectares of dryland, reducing crop yield by an average of 25 percent.
- Of 650 000 hectares of surveyed land in the irrigated part of the province, 12.4 percent were affected by salinity related to irrigation and 13.5 percent were affected by dryland salinity.
- Data from 1991 show that 83 percent of the farms reporting used conventional tillage, 21 percent used conservation tillage and 5 percent used no-till.
- Since 1989, more than 144 000 hectares of environmentally sensitive farmland in Alberta was returned to permanent cover of grass or trees.
- There are more than 400 000 hectares of strongly acid and 1.8 million hectares of moderately acid soils farmed in Alberta.

FUTURE DIRECTIONS

- Continued efforts to improve resource management and environmentally sound management practices through federal and provincial cost-sharing under the Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA).
- Provision of support, through CAESA, for research and education related to the adoption of more environmentally friendly practices of primary production and agricultural processing.
- Continued work between the provincial and federal government advocating change in farm policies to those policies that have less impact on the land.
- Development of agricultural indicators for future reporting.

5.3 MINERAL RESOURCES

In Alberta, conventional oil, oil sands, natural gas, coal, and sand and gravel are the principal mineral resources. The development of these resources is highly regulated through legislation, regulations and guidelines issued by the Energy Resources Conservation Board (ERCB) and Alberta Environmental Protection.

A. PRESENT CONDITIONS

Almost three-quarters of the energy produced in Canada comes from Alberta. As a result, the Alberta land base bears the direct impact of energy resource extraction activities. As most of the Alberta-produced energy resources are consumed outside Alberta, the impact of the development of these resources in terms of surface disturbance is concentrated at the source, whereas the benefits of the product are enjoyed at the point of consumption.

In 1992, Alberta's hydrocarbon reserves accounted for an estimated 67 percent of Canada's total reserves of fossil fuels. Alberta has about 85 percent of the country's conventional oil and gas reserves, 57 percent of the coal reserves and all of Canada's oil sands reserves. By the end of 1992, Alberta's reserves of conventional oil and pentane were approximately 21 500 petajoules; natural gas and natural gas liquids about 64 900 petajoules; bitumen and synthetic crude oil about 18 000 petajoules; and coal about 684 000 petajoules.

Estimates of Alberta's reserves of mineral resources are derived from data on exploration and production. Exploration and production depend on many factors, including the price received for the product, the costs of production, growth in the economy, demand and exchange rates and the impacts of new technologies and processes. Estimates of the province's reserves of oil, gas and coal have fluctuated over the years because of changes in these factors.

B. STRESSES

Oil and Gas Wells

The location of Alberta's reserves show where some of the potential impacts may occur. Figure 5.6 shows the approximate location of these reserves.

Figure 5.6 Alberta Mineral Deposits.

Source: Energy Resources Conservation Board, 1992b.

Stress on the environment occurs when these minerals are extracted. Roads are constructed and wells drilled often resulting in temporary changes in land use. As an average, each wellsite covers an area of 1 hectare. However, many wellsites are substantially smaller than 1 hectare, and many oil sands, bitumen and synthetic oil developments cover more than 1 hectare. Figure 5.7 shows the number of oil and gas wells drilled in Alberta from 1956 to 1992, and Table 5.9 shows the number of active and inactive wells drilled in Alberta up to and including 1993.

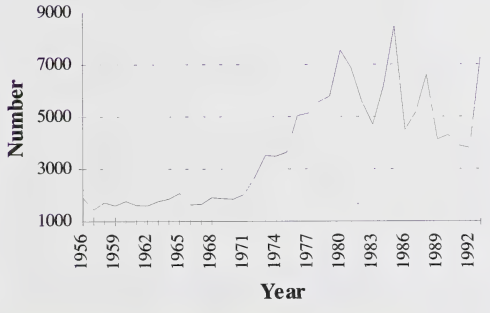


Figure 5.7 Oil and Gas Wells Drilling.

Source: Mineral Resources Branch, Alberta Energy.

Table 5.9 Alberta Oil and Gas Wells.

Active*	92 500
Inactive**	57 500
Total	**150 000**

* Includes location, suspended and injection wells (up to and including 1993).
** Includes all abandoned wells (up to and including 1993).

Source: Mineral Resources Branch, Alberta Energy.

Pipeline Construction

A second indicator that describes a stress on the land resource is the total area of pipelines constructed in the province. Although regulators set strict environmental standards for pipeline construction and operation, the construction of pipelines results in short-term and long-term disturbances to the land's surface and to wildlife. Table 5.10 provides information on pipelines and pipeline permits.

Table 5.10 Pipeline Construction in Alberta.

	Licences Received	Permits Received	Diameter x Length (square metres)
1987	2 450	2 145	1 009 249
1988	2 327	2 106	1 215 927
1989	2 373	1 861	1 456 589
1990	2 552	2 122	1 588 203
1991	2 929	1 994	938 706
1992	2 338	1 931	1 182 919
1993	2 358	3 246	2 666 026

Source: Pipeline Division, Energy Resources Conservation Board.

Cutlines From Oil and Gas Seismic Exploration

Another environmental indicator that helps to show the impact of mineral development in the province is the area of cutlines approved for seismic exploration. Table 5.11 shows the number of kilometres approved for cutlines and the approximate area of the actual cutlines between 1986 and 1992.

Sand and Gravel Removal

Another land use activity that stresses the land resource is the removal of sand and gravel from the earth's surface and subsurface. An indicator to describe this stressor is the number of dispositions issued for sand and gravel removal on public land and the actual volume of material removed. This information is presented in Table 5.12.

New Exploration

Over the past several years, there has been new interest in other minerals in the province. Diamond exploration, for example, has recently received considerable attention. There are not yet any indicators, however, that show the impacts of this exploration.

Table 5.11 Length and Area of Cutlines in Alberta, 1986 to 1992.

Kilometres Approved for Cutlines

1986	1987	1988	1988	1990	1991	1992
44 831	57 270	46 852	44 982	51 542	24 556	27 409

Approximate Area of Cutlines

1986	1987	1988	1989	1990	1991	1992
200 km^2	300 km^2	200 km^2	200 km^2	300 km^2	100 km^2	100 km^2

Note: Seismic lines must be reclaimed, but reclamation data are not available.

Source: Land and Forest Services, Alberta Environmental Protection.

Table 5.12 Sand and Gravel Dispositions in Alberta.

	1991-92	1992-93	1993-94
Number of dispositions in effect at fiscal year end			
Surface Materials Lease	682	687	694
Surface Materials Licence	41	29	44
Public Pit Licence	79	75	68
Number of dispositions issued for fiscal year			
Surface Materials Lease	82	77	77
Surface Materials Licence	55	50	71
Public Pit Licence	391	350	337

	1991	1992	1993
Volume of Material removed (cubic metres)			
Surface Materials Lease	329 436	812 210	31 410
Public Pit Licence	403 468	346 812	290 069
Total	**732 904**	**1 159 022**	**420 234**

Surface Materials Lease provides long-term land tenure for the removal of surface materials. For the data in this table, the dispositions that specifically pertain to sand and gravel have been separated out.
Surface Materials Licence has a term of one year or less and a specified volume of materials to be removed.
Source: Land and Forest Services, Alberta Environmental Protection.

C. ACTIONS

Well Abandonment Strategies

Well abandonment refers to the proper shutdown and clean-up of wells that have been abandoned. Proper well abandonment helps to ensure that wells that are no longer producing oil or gas do not pose an environmental threat to either surface or subsurface aquifers.

In July 1993, the ERCB implemented a new strategy for dealing with well licence transfers. New well licence transfer criteria ensure that a company recognizes its well abandonment responsibilities when it acquires or sells wells. As part of any well licence transfer, ERCB staff check

that a new owner is in a financial position to cover the eventual cost of the proper abandonment of all wells it owns. The seller is also required to retain an adequate level of coverage. In this way, the directive provides strong incentive for companies to reduce their inventory of inactive wells.

During 1993, the ERCB coordinated the abandonment of 25 orphan wells on behalf of the industry orphan well fund (orphan wells have no owners, little or no value, and have not been properly abandoned or reclaimed). The ERCB has also carried out well abandonment on 11 wells and plans to carry out abandonment on about 40 more in 1994-95.

Land Reclamation

Table 5.13 lists the area of land disturbed, reclaimed and certified in 1993 for coal mining and oil sands activities. In addition, over 40 000 reclamation certificates have been issued to date for oil and gas wellsites, with about 740 certificates issued in 1993. To date, about 200 pipelines have received reclamation certificates.

New Techniques and Technologies Minimizing Surface Impacts

Recent advances in horizontal and directional drilling have significantly reduced impacts associated with oil and gas development. Unlike a standard vertical well, horizontal wells turn at an angle when an oil pool is reached and contact a larger area within the pool. As a result, additional wells, which would result in more environmental impacts, do not need to be drilled. Directional drilling allows for drilling at an angle. Using this technique, petroleum resources under a lake, for example, can be accessed from the shore.

Using this new technology, oil and gas producers are making greater use of previously used wellsites, removing the need for more road access and pipelines. An additional benefit is that a single drilling pad can be used to directionally or horizontally drill in areas where several drilling pads would have been required previously. Consequently, there is less surface disturbance and less disruption of wildlife than with other methods of drilling.

The Alberta Oil Sands Technology and Research Authority (AOSTRA) has developed a way to recover large amounts of oil from the oil sands by tunnelling underground in a mine shaft and drilling up under the oil sands. Extremely large recoveries might be possible with most of the disturbance occurring under ground.

Other recent advances relating to seismic exploration have also reduced the impact on the land surface. For example, low impact seismic exploration and helicopter-assisted seismic exploration are reducing the impacts associated with such exploration. In some cases, cutlines are now narrower than in the past, resulting in less wildlife and forest disturbance. Surface impacts and wildlife disruptions have also been reduced through new remote monitoring technologies.

Table 5.13 Land Disturbance Report for Alberta.

	1993			Total		
	Disturbed	Reclaimed	Certified	Disturbed	Reclaimed	Certified
Coal Mining						
Mountains/Foothills	528	256	0	6 729	2 927	927
Plains	506	156	63	8 476	4 105	1 408
Oil Sands Mining	1 140	204	0	12 512	2 122	0
Oil Sands in Situ	92	53	0	2 577	158	13
Totals:	**2 266**	**690**	**63**	**30 294**	**9 312**	**2 348**

Note: All data given in hectares.

Source: Environmental Regulatory Service, Alberta Environmental Protection.

KEY POINTS

- Almost three-quarters of the energy produced in Canada comes from Alberta.
- There are about 150 000 active and inactive oil and gas wells in Alberta, each covering approximately 1 hectare of land.
- Oil sands activity and coal mining affect over 30 000 hectares of land to date, of which over 9000 hectares have been reclaimed.
- Sand and gravel removal also stresses the land resource. In 1993, approximately 420 000 cubic metres of material was removed from public land alone.
- The construction of pipelines results in disturbance to the land surface and to wildlife. From 1987 to 1993, there was approximately 1.4 million square metres of pipeline constructed each year.
- In 1993, the Energy Resources Conservation Board coordinated the abandonment of 25 orphan wells.
- New mineral extraction technology, such as horizontal and directional drilling, is reducing the environmental impacts of oil and gas development.

FUTURE DIRECTIONS

- Alberta Energy and Alberta Environmental Protection will continue to encourage industry efforts to develop new mineral extraction and land reclamation technology.

5.4 WETLANDS

Wetlands are natural ecosystems that occur throughout Alberta where the ground is saturated with water or is flooded for a period of time. Water up to 2 metres in depth is generally considered the upper limit for wetland vegetation. Most of the wetlands in Alberta can be classified as either marshlands or peatlands.

Marshlands include deep and shallow marshes, shallow open water, mudflats and wet meadows. They develop on mineral soil and are characterized by fluctuating and emergent aquatic vegetation like reeds, rushes and sedges.

Peatlands include many different types of bogs and fens. They have peat accumulations of at least 40 centimetres thickness and are characterized by relatively stable and vegetation dominated by mosses, sedges and often shrubs and stunted trees.

A. PRESENT CONDITIONS

Wetlands cover approximately 13.7 million hectares of Alberta (excluding large open water areas), or about 20 percent of the province's land base. The type and extent of wetlands are determined by climate, land features, surface and groundwater flow, vegetation and soils.

On a provincial scale, peatlands are far more extensive than marshlands. But the wetlands, primarily marshlands, that occur in the White Area have been most intensively studied. Table 5.14 below presents some detailed information on the extent of wetlands in the White Area.

Marshlands are the primary type of wetland of the grasslands and parklands, and they are common along the margins of the boreal forest. There are about 1.1 million marshlands in the White Area and 90 percent of them are less than 2 hectares in area. Marshlands can also be found along gently sloping lake shores throughout the boreal region. The largest marshland complex in the province is the Peace-Athabasca Delta. This area is one of the largest freshwater deltas and the largest boreal delta in the world.

Peatlands occur in the cool, wet boreal environments of the northern half of the province. Fens are most common in the southern boreal, whereas bogs become dominant in the north. From south to north, the size of the peatlands tends to increase. In the far northern areas, permafrost underlies the bogs, and peatlands may cover 75 to 100 percent of the landscape.

Table 5.14 Extent of Wetlands in the White Area of Alberta.

	Wetland Area (km^2)			% of total	Number of
	Marshland	Peatland	Total	Land Area	Marshlands
Grassland Natural Region					
Dry Mixedgrass	1 907	--	1 907	4.3	193 497
Foothills Fescue	275	--	275	2.5	223 092
Northern Fescue	846	--	846	6.6	101 272
Mixedgrass	687	--	687	3.3	86 106
Subtotal	**3 715**		**3 715**	**3.8**	**403 967**
Parkland Natural Region					
Central Parkland	4 089	166	4 255	7.5	416 461
Boreal Forest Natural Region					
Dry Mixedwood (and Peace River Parkland)	5 838	11 387	17 225	18.9	251 031
Rocky Mountain Natural Region					
Montane (Cypress Hills portion only)	19	--	19	3.5	2 723

Source of the raw data was Ducks Unlimited Canada wetland inventory data (1985-1989). Results of analysis by Strong et al., 1993 were reworked to provide Natural Region summaries.

Wetland Values

From an ecological perspective, Alberta's wetlands are very important. Wetlands are highly productive and dynamic ecosystems that are significant sources of genetic diversity. Wetlands play a key role in surfaces water hydrology, including groundwater flow, flood control and soil moisture. They influence water quality by filtering out sediment and accumulating nutrients in plant tissue. Wetlands provide habitat for many species of wildlife, particularly waterfowl, and support rare or endangered wildlife (e.g., the trumpeter swan).

Wetlands also provide a variety of social and economic benefits. There are many tourism and recreation opportunities, including bird watching and hiking, provided by wetlands. Wetlands may function as sites for research and education. The harvesting of resources such as wild rice, hay or peat moss occur in wetlands. Wetlands are home to many animals that are important for hunting, fishing, trapping and wildlife appreciation (e.g., nature photography). Permanent wetlands may be used to supply water for domestic or livestock use. Some wetlands may control soil erosion or downstream sedimentation. Wetlands may be important for agricultural purposes, including grazing, forage production and cropping on peat soils.

B. STRESSES

The White Area

The marshlands of the White Area are under significant stress. From 1970 to 1990, there was about a 30 percent reduction in the number of marshlands. Approximately 30 percent of this loss can be attributed to the warm, dry weather experienced during the 1980s, whereas the remainder is probably the result of wetland drainage. Assuming a constant rate of land development and wetland loss, the existing White Area wetlands represent approximately 37 percent of the wetlands that may have existed prior to settlement in the 1880 to 1890 period. Table 5.15 ummarizes the change in the number of marshlands for the 1970 to 1990 period.

Table 5.15 Index of Change in Number of Marshlands for the Period 1970 to 1990 by Natural Region.

	% Change
Grassland Natural Region	
Dry Mixedgrass	-37.7
Foothills Fescue	-35.8
Northern Fescue	-35.4
Mixedgrass	-15.0
Parkland Natural Region	
Central Parkland	-32.9
Boreal Forest Natural Region	
Dry Mixedwood (and Peace River Parkland)	-35.0
Rocky Mountain Natural Region	
Montane (Cypress Hills portion only)	+2.2

Based on Canadian Wildlife Service annual spring marshland counts for a sample of the lands in the Settled Area of the province. Results of analysis by Strong et al., 1993 were resorted to provide Natural Region summaries.

The drainage of marshlands for agriculture has been the major cause of wetland loss in the White Area. In areas where soil salinity is a problem, drainage of upslope wetlands is used to reduce the spread of dryland salinity in low lying areas (see Section 5.2C). Wetlands have also been drained to accommodate urban, transportation and utility development. The cumulative effect of draining individual wetlands has resulted in a significant total loss of wetlands.

An analysis of wetland vulnerability in the White Area suggests that the Central Parklands are probably the most sensitive to future loss of wetlands. Wetlands in this area are highly susceptible to loss because of their small size, high density and their occurrence in an intensively developed area.

The peatlands that occur in the areas of transition between the settled areas and the boreal forest, especially in the Dry Mixedwoods, are the peatlands that have been subject to the greatest pressure. This pressure has come in the form of agricultural use and peat harvesting and has occurred because of the proximity of these areas to existing infrastructure.

The Green Area

Compared to the wetlands in the White Area, Green Area wetlands have been relatively unaffected by human activity. Impacts to date have tended to be localized and may be so long-term in nature that they are not fully recognized.

The major impacts on Green Area wetlands are from agricultural activities, timber harvesting, peat harvesting and the construction of roads, wellsites and recreational facilities.

One wetland ecosystem in the Green Area that has been significantly affected by man is the Peace-Athabasca Delta. The Peace River in British Columbia was dammed in 1968. Since then the magnitude and frequency of major water level fluctuations, which are essential for the long-term survival of this marshland ecosystem, have been reduced. The delta has been gradually drying and woody vegetation has been replacing the productive marshlands. Remediation efforts were made in the 1970s, and in 1993 a program of technical studies was initiated that was aimed at better understanding how to manage this dynamic ecosystem.

C. ACTIONS

North American Waterfowl Management Plan

The North American Waterfowl Management Plan (NAWMP) is currently the most significant initiative benefiting wetlands in Alberta and is the largest habitat conservation undertaking in history. Programs are designed to stem the loss of wetlands and wetland-related wildlife habitat. Signed in 1986, NAWMP involves all levels of government in the United States, Canada, Mexico and private wildlife agencies as well as thousands of citizens.

Staff from the Alberta NAWMP Centre, Alberta Environmental Protection's Fish and Wildlife Services from Ducks Unlimited and other provincial partners work with organized groups and with individual farmers and ranchers to establish conservation practices and land management options that are sustainable for agriculture and benefit the wetland ecosystems.

To March 1994, NAWMP has spent about $54 million on habitat activities in Alberta. There are now close to 100 000 hectares of land where agreements are in place for enhancement or management. These agreements include the management of small wetland complexes and large waterfowl staging and moulting wetlands, as well as the restoration or management of the adjacent uplands on which many wetland species depend. More information on the NAWMP is provided in Section 6.0C.

Wetland Policy for Alberta

In answer to growing concerns about the loss of wetlands, Alberta Environmental Protection is developing a wetland management policy for the province. The policy provides direction for the conservation and management of wetlands throughout Alberta. The goal of the policy is to sustain the environmental, economic and social benefits that wetlands provide, now and in the future.

A wetland policy for the the White Area of the province has been approved by Cabinet and is in the implementation phase. Current activities include the development of regional wetland management strategies, raising public awareness of the policy and distributing educational materials on wetlands.

For the Green Area, the wetland policy is undergoing governmental and public review and is nearing completion. These two policies are being combined into a unified provincial wetland policy.

KEY POINTS

- Wetlands cover approximately 13.7 million hectares of Alberta, or about 20 percent of the province's land base.
- 90 percent of the 1.1 million marshlands in the White Area are less than 2 hectares in area.
- From 1970 to 1990, there was a 30 percent reduction in the number of marshlands, due primarily to wetland drainage and secondarily to the dry climate of the 1980s.
- About $45 million has been spent in Alberta on wildlife habitat activities through the North American Waterfowl Management Plan.

FUTURE DIRECTIONS

- A wetland management policy for Alberta is being developed to provide direction for the conservation and management of wetlands.

5.5 PROTECTED AREAS

There are a several types of protected areas in Alberta, differing in purpose and level of protection. Based on national and international criteria on what is required to be considered protected, such areas must be legislated with the primary purpose of conserving their inherent natural value. In Alberta, protected areas are considered to include National Parks, National Wildlife Areas, Wilderness Areas, Wilderness Parks, Ecological Reserves, Provincial Parks and Natural Areas (see Section 5.5C). Explanation of these classifications is provided in Table 5.16.

In addition to legislated protected areas, there are other mechanisms for managing ecosystems in Alberta. Through Alberta's land use planning systems, land use categories are established to manage sensitive areas (such as prime protection and critical wildlife zones). The objectives of other designated areas such as Wildlife Sanctuaries, Forest Land Use Zones and Recreation Areas are, respectively, to control hunting, to restrict or permit motorized vehicle use and to provide recreational opportunities. The data on private nature conservation initiatives have not been compiled.

A. PRESENT CONDITIONS

Currently, more than 9 percent of Alberta is designated as protected area. Figure 5.8 shows the number of sites and the amount of land designated for protection within the natural regions and subregions of Alberta. However, to determine whether the diversity of a subregion has been adequately protected, the natural features themselves must also be considered.

In developing a protected areas system, the first element is to adopt criteria for protected areas. The next element is to develop a framework describing the range of natural features and ecological processes that need to be represented in protected areas. The Natural Regions and Subregions of Alberta (see Section 2.0) and the Natural History Theme Matrix are the frameworks that are used in Alberta.

The Natural History Theme Matrix is a hierarchical system that identifies representative features of each natural subregion at increasing levels of detail, the first level being the most general. The matrix is being refined as more detailed ecological inventory data become available; the first 2 levels have been completed. In addition to identifying gaps in the protected areas system, the matrix will be used to evaluate sites that have been nominated (see Section 5.5C).

Figure 5.9 summarizes the trend in designating protected areas. There have been a few significant periods in the development of protected areas in Alberta. By far the greatest land area (87 percent of the currently protected area) was designated before 1930, as national parks by the federal government. During 1930 to 1950, the first provincial parks were established. Generally, they were relatively small and recreation-oriented. The second-most significant additions (based on area contribution) occurred in the 1950 to 1960 period with the designation of Willmore Wilderness Park (8.1 percent of the total protected area). The 1960 to 1970 period saw the establishment of the three current wilderness areas, contributing 1.8 percent to the total protected area. Since 1970, additional provincial parks, natural areas and the first ecological reserves have been established, representing from 0.7 to 1.3 percent per decade of the total protected area.

The completion of a protected areas system that represents the full diversity of landscapes and ecological processes within the province depends on protecting additional areas before options become too expensive or are lost altogether.

Size of Protected Areas

The International Union for the Conservation of Nature considers 1000 hectares (approximately 1/20 the size of Elk Island National Park) to be the minimum size for a site to be included on the official United Nations list of protected areas. Figure 5.10 illustrates the size distribution of Alberta's protected areas. In Alberta, 47 protected areas are larger than 1000 hectares. Figure 5.11 shows the number of each type of protected area that meets this criteria.

B. STRESSES

Development Activities

The range of protected area legislation in Alberta allows differing types and levels of development, from no development to intensive development. Fragmentation of habitat within protected areas

Table 5.16 Types of Legislated Protected Areas in Alberta.

National Parks

National parks are representative examples of the natural regions of Canada set aside to protect their flora, fauna and other natural features. They are legislated under the *National Parks Act* and provide a high level of protection for their natural resources.

National Wildlife Areas

National Wildlife Areas are important or unique lands for wildlife that are administered in accordance with the *Canada Wildlife Act* and the Wildlife Area regulations. National Wildlife Areas are managed to preserve or increase their value to wildlife.

Wilderness Areas

Wilderness areas are large areas of undeveloped land protected to conserve their character without permanent improvements or human habitation. They are legislated under the *Wilderness Areas, Ecological Reserves and Natural Areas Act.*

Wilmore Wilderness Park

Wilmore Wilderness Park was established under its own legislation. The park provides opportunities for hiking, horseback riding, cross-country skiing, hunting and fishing, and also conserves sensitive wildland resources.

Ecological Reserves

Ecological resources are selected representative areas or special natural landscapes and features of the province, protected as examples of functioning ecosystems, as gene pools for research, and for education and heritage appreciation purposes. The legislation guiding the program is the *Wilderness Areas, Ecological Reserves and Natural Areas Act.*

Provincial Parks

Provincial parks protect outstanding recreational resources and provincially significant natural landscapes and features to provide quality recreational and educational experiences. Provincial parks are legislated under the *Provincial Parks Act*, which generally precludes extractive and industrial uses.

Natural Areas

Natural areas are special parcels of public land that contain natural features representing one or more aspects of the province's biological and physical diversity. Natural areas are intended for low levels of public use, so the natural characteristics of the sites are maintained. They are legislated under the *Wilderness Areas, Ecological Reserves and Natural Areas Act.*

from linear disturbances (such as roads, railways, pipelines, power lines and seismic lines) occurs, although few detailed, quantitative data on area of disturbance are available. It has been estimated that 24 percent of the Montane Natural Region in Banff and 12 percent in Jasper have been disturbed or impacted by development (townsites, facilities, roads, railways, trails). Ecological impacts from visitor use are monitored in only a few provincial parks; however, trends of the level of use can be obtained from user statistics.

Oil and gas exploration and development is permitted in 67 percent, and has occurred in 20 percent of the province's natural areas. Oil and gas activity occurs in 36 percent of the ecological reserves and in seven of the provincial parks. Grazing occurs in seven provincial parks (in ecological reserves and provincial parks the activities pre-dated the designation). Logging has occurred in Wood Buffalo National Park, Cypress Hills Provincial Park and Moonshine Provincial Park. Hunting is permitted in over 95 percent of designated natural areas.

Intensive recreational development occurs in most provincial parks. Trends of the level of use can be obtained from visitor statistics. In the period 1987-88 to 1992-93, the total number of individual visits to provincial parks (including recreation areas and Kananaskis Country) increased by 28 percent. There was a decline of 2.8 percent in individual visits in 1992-93 from the previous year. Visitor statistics are not collected for ecological reserves, natural areas or wilderness areas/parks.

External threats to the ecological integrity of protected areas include their isolation from the surrounding landscape due to development on adjacent lands, downstream effects from dam

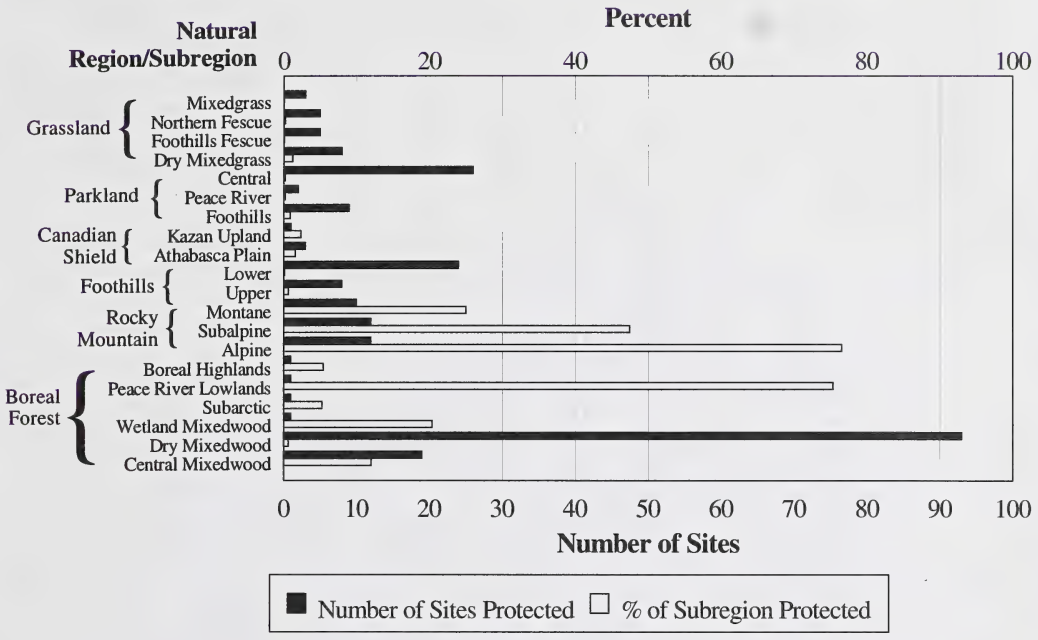


Figure 5.8 Number of Sites and Percentage of Subregion Protected.

Source: Parks Services, Alberta Environmental Protection.

development, air and water emissions from industrial and municipal development, invasion of noxious weeds and exotic species from surrounding land, and the suppression of natural processes such as wildfire.

There is no final estimate of the amount of remaining "wilderness," from which additional protected areas could be selected. Only preliminary estimates are available on the amount of land remaining in a natural state. More than 80 percent of the native prairie landscape has been transformed by agriculture or urbanization. More than 60 percent of the prairie's wetlands have been drained or cultivated. Approximately 90 percent of the Fescue Prairie has been cultivated with much of the remaining land modified by livestock grazing and haying. About 24 percent of the mixed prairie (roughly equivalent to the Mixed, Dry Mixed and Northern Fescue Grassland subregions) and 25 percent of the aspen parkland (roughly equivalent to the Central Parkland subregion) remain in a native state.

C. ACTIONS

Commitment to Complete Canada's Network of Protected Areas

The federal government and the provinces have committed to complete Canada's network of protected areas at several fora:

- In March 1992, the National Forest Congress endorsed a framework for action to protect and manage Canada's forests. A component of this framework was that "...all members of the forest community will work towards completing by the year 2000 a network of protected areas representative of Canada's forests, to provide

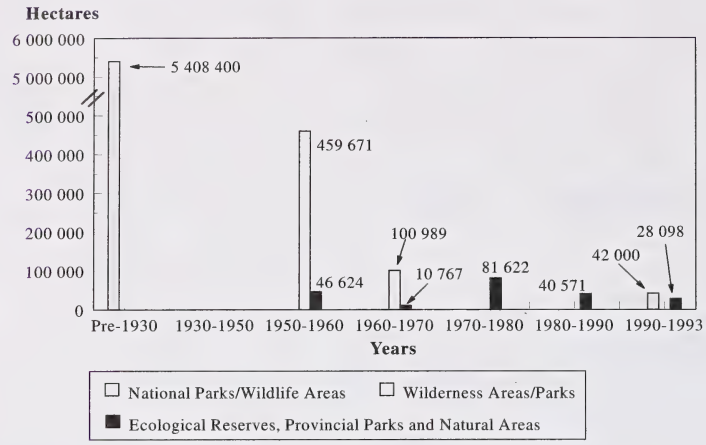


Figure 5.9 Chronology of Protected Area Designated in Alberta.

Source: Parks Services, Alberta Environmental Protection.

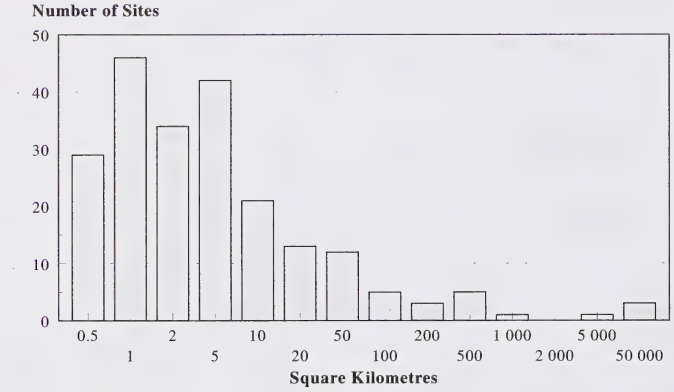


Figure 5.10 Size Distribution of Protected Areas in Alberta.

Source: Parks Services, Alberta Environmental Protection.

ecological benchmarks, protect areas of unique biological value and ensure wilderness experiences."

- In November 1992, the environment, parks and wildlife ministers committed to "...complete Canada's networks of protected areas representative of Canada's land-based natural regions by the year 2000...".

- In November 1994, the Canadian Council of Ministers of the Environment reviewed the Canadian Biodiversity Strategy and noted that Canada's biological diversity is threatened, and that there is a need to take action to protect the wide variety of Canada's native species and natural habitats.

In response to the above commitments, the government is preparing a "made in Alberta" initiative to complete the protected areas network by the year 2000. This initiative (i.e., Special Places 2000) is being undertaken in partnership with other departments and agencies and the public. A complete protected areas system will include the full range of natural landscapes, environmental diversity and unique natural features of Alberta. Targets for levels of protection within each natural region have been identified in Table 5.17.

There are four goals for the protected areas system: protection, outdoor recreation, heritage appreciation and tourism. Sites nominated to meet the protection goal will be evaluated using the long accepted Natural Regions Framework which has been refined over the last 20 years. The Level 1 Natural History Theme Matrix will be used to identify gaps in the current protected areas system and to set priorities for protection.

Figure 5.12 illustrates the proportion of each subregion's currently protected Natural History Theme Level 1 target. Four of 20 natural subregions (Alpine, Subalpine, Montane and Peace River Lowlands) have full representation of their Level 1 themes. The Kazan Upland subregion has

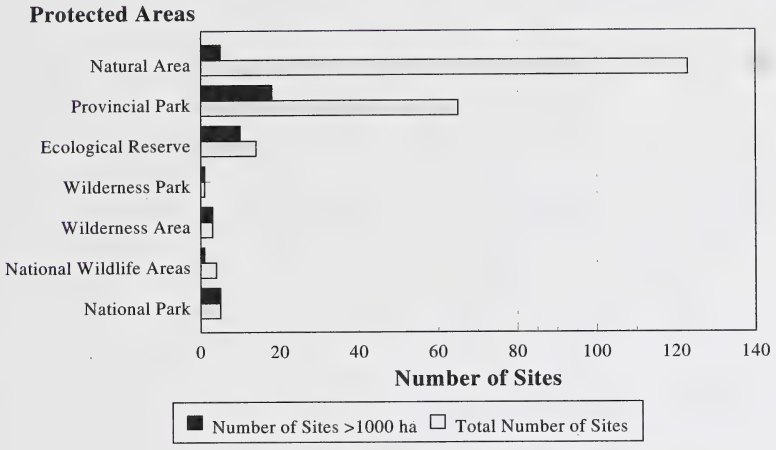


Figure 5.11 Number of Alberta Protected Area Sites Greater Than 1000 Hectares in Size.

Source: Parks Services, Alberta Environmental Protection.

Figure 5.12 Percentage of Natural History Theme Level 1 Targets Protected in Alberta Subregions.

Source: Parks Services, Alberta Environmental Protection.

no protection of Level 1 themes. In total, approximately 48 percent of all Level 1 targets are protected within the existing legislated protected areas.

National and International Designations

Alberta joined the Canadian Heritage Rivers Systems Program in 1993. The Canadian Heritage Rivers System program is federal-provincial in nature, involving both levels of government. The program aims for long-term management of

Table 5.17 Level 1 Theme Targets by Subregion.

Level 1 Themes		Grassland				Parkland			Foothills	
		Dry Mixedgrass	Mixedgrass	Northern Fescue	Foothills Fescue	Central	Foothills	Peace River	Lower	Upper
Upland	Glacial Lake Bed	200	25	100	25	250	25	50		
Non-Sandy	Ground Moraine	200	50	100	100	250	100			
	Hummocky Moraine	200	50	100	25	250				
	Bedrock									
Sandy	Sandy Plain	200	25	25	25	250				
	Dune Field	200	25	25		100				
	Kame/Moraine Complex					100				
Valley/ Ridge	Exposed Slope	100	25	25	10	25	10	25		
	Protected Slope	25	25	10	10	25	10	25		
	Floor/Stream	100	25	25	25	25	25	10	100	100
	Ridge/Valley Wall				25		25		500	500
	Springs	2.5	2.5	2.5	2.5	2.5	2.5			
Wetland	Wet Meadow	10	2.5	10	10	10	10	10		
	Shallow Marsh	2.5	2.5	10	10	10	10	10		
	Deep Marsh	2.5	2.5	2.5	2.5	10	10	10		
	Alkali Wetland	10	2.5	2.5		10				
	Mineral								250	50
	Organic								250	50
	Lake			10		100		10	25	10
Glacier/Snowfield										
TOTALS		1252.5	263	448	270	1418	228	150	1125	710
Target as % of SubRegion		0.027%	1.4%	2.9%	1.8%	2.7%	5.2%	3.2%	1.7%	2.4%

Note: All data in hectares.

Source: Parks Services, Alberta Environmental Protection.

Table 5.17 (continued).

Level 1 Themes		Rocky Mountain			Boreal Forest						Canadian Shield	
		Montane	Subalpine	Alpine	Dry Mixedwood	Central Mixedwood	Wetland Mixedwood	Boreal Highlands	Peace River Lowlands	Subarctic	Athabasca Plain	Kazan Upland
Upland	Glacial Lake Bed				250				100			
Non-Sandy	Ground Moraine				250	400	250	250		250		
	Hummocky Moraine				250	400	250	250				
	Bedrock											100
Sandy	Sandy Plain				250	400	150				100	100
	Dune Field				250	400					100	
	Kame/Moraine Complex										100	
Valley/ Ridge	Exposed Slope				100	100						
	Protected Slope				100	100		100		250		
	Floor/Stream	100	100	100	250	250	100	150	100		10	10
	Ridge/Valley Wall	500	500	500								
	Springs											
Wetland	Wet Meadow											
	Shallow Marsh											
	Deep Marsh											
	Alkali Wetland											
	Mineral	10	25	25	100	400	250	100	100	250	25	25
	Organic		10		100	400	250	250	100	250	25	25
	Lake	10	10	10	100	400	250	25		25	25	100
Glacier/Snowfield				10								
TOTALS		620	645	645	2000	3250	1500	1125	400	1025	385	360
Target as % of SubRegion		10.4%	2.5%	4.4%	2.0%	2.1%	3.9%	5.3%	4.0%	4.7%	5.4%	4.0%

Source: Parks Services, Alberta Environmental Protection.

Canada's important rivers. Alberta has begun a study of all major rivers in the province to determine which rivers meet the criteria for designation under the program. After the study is completed, the nomination and establishment of additional heritage rivers will follow. Portions of two rivers (Athabasca and North Saskatchewan) within the national parks have been designated as Canadian Heritage Rivers by the federal government.

International designations of protected areas in Alberta include one Biosphere Reserve (Waterton Lakes National Park), four World Heritage Sites (Dinosaur Provincial Park, Canadian Rocky Mountain Parks, Wood Buffalo National Park and Head-Smashed-In Buffalo Jump), and four wetlands of international significance (Whooping Crane Summer Range, Peace-Athabasca Delta, Hay-Zama Lakes and Beaverhill Lake).

Other Initiatives

There are some other initiatives in the province related to conservation, not involving legislated protected areas. The Prairie Conservation Action Plan (PCAP), a result of the Wild West program developed by the World Wildlife Fund, is a cooperative effort of landowners, government and nongovernment organizations to conserve the biological diversity of the Canadian prairies. By implementing the PCAP, populations of many wildlife species are being recovered, thereby maintaining the species diversity in areas of the province.

Conservation of wetlands is being pursued by Ducks Unlimited and in cooperation with other government and nongovernment agencies and landowners through the North American Waterfowl Management Plan (see Section 6.0C). Private conservation initiatives include land acquisition by The Nature Conservancy of Canada.

KEY POINTS

- National Parks, National Wildlife Areas, Wilderness Areas, Wilderness Parks, Ecological Reserves, Provincial Parks and Natural Areas are classifications of protected areas. These types of protected areas differ in their purpose and level of protection.

- Currently, more that 9 percent of Alberta is under protected area status.

- The most significant periods of protected areas development in Alberta occurred before 1930 when 87 percent of the currently protected area was designated, and between 1950 and 1960 with the designation of Willmore Wilderness Park.

- In Alberta, 47 protected areas exceed the International Union for the Conservation of Nature's criterion of 1000 hectares as the minimum size of a protected area.

- In total, approximately 48 percent of all Level 1 targets are protected within the existing legislated protected areas.

- Protected areas legislation in Alberta allows for different types and levels of development to occur in protected areas.

- Land disturbance over the past 100 or so years also affects the amount of land remaining in a natural state that could be used to select new protected areas. Preliminary estimates indicate that human activities have disturbed:

    - more than 80 percent of the native prairies;
    - more than 60 percent of the prairie's wetlands;
    - about 90 percent of the fescue prairie;
    - approximately 76 percent of the mixed prairie; and
    - about 75 percent of the aspen parkland.

- Portions of two Alberta rivers have been designated as protected under the Canadian Heritage Rivers System Program.

FUTURE DIRECTIONS

- A government initiative to complete Alberta's system of protected areas by the year 2000 is currently under review.

- A study of Alberta rivers for designation under the Canadian Heritage Rivers System Program will be completed.

5.6 WASTE MANAGEMENT

The generation of waste affects every facet of the environment. Waste in the form of air emissions is discussed in Section 3.0; waste in the form of effluent discharge to watercourses is discussed in Sections 4.0 and 5.2. Another category of waste is solid waste: that generated directly by people day in and day out, at home and in the workplace. For the purposes of this report, this human-generated waste has been classified as municipal waste and special waste.

A. MUNICIPAL LANDFILLS

Figure 5.13 shows the typical composition of municipal solid wastes. Landfilling is the most common method for disposal of this waste. In Alberta, there are approximately 340 approved municipal landfills in operation. Although the rate of approvals for new landfill sites has not decreased, the approval process is becoming more complex. The public is concerned with the potential impacts of landfill development and is demanding more input into the approval processes used by local planning authorities and regional health authorities. Many municipalities are recognizing the value of their existing waste disposal facilities and are taking steps to extend their useful lives through improved equipment and management techniques.

In the early 1970s, many of the landfills in Alberta were unsupervised and were a source of environmental contamination, including smoke, litter, pests and water pollution. Since 1976, 28 regional waste management systems have been developed to serve 156 urban and rural municipalities. Over 220 small waste disposal sites have been replaced by 24 larger regional sanitary landfills and 160 waste transfer stations. This restructuring, combined with changes to the Waste Management Regulation and increased enforcement by local Health Units, has resulted in a substantial reduction in complaints and concerns about pollution.

As of March 1994, seven new regional landfill systems were currently at varying stages of development in the province, and 16 other groups of municipalities were considering regionalizing their waste management facilities (Figure 5.14). New systems in these areas would eliminate small waste disposal sites. Some isolated areas, however, may never need to develop regional systems because of their sparse populations and the relatively high capital costs associated with system development.

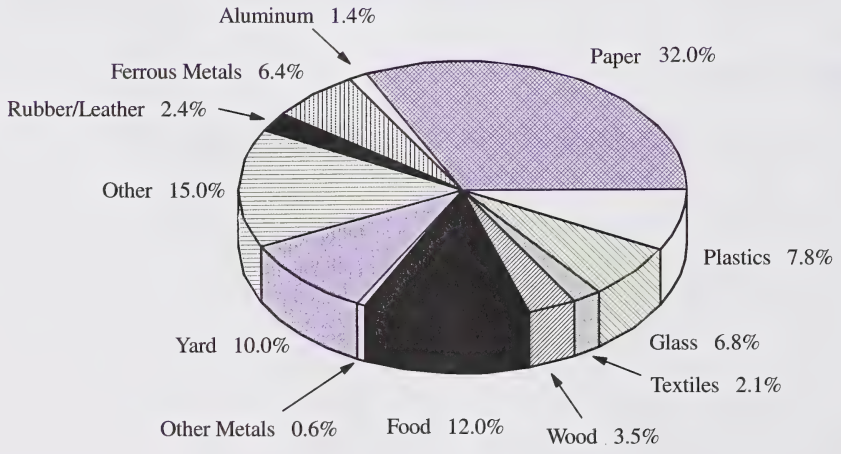
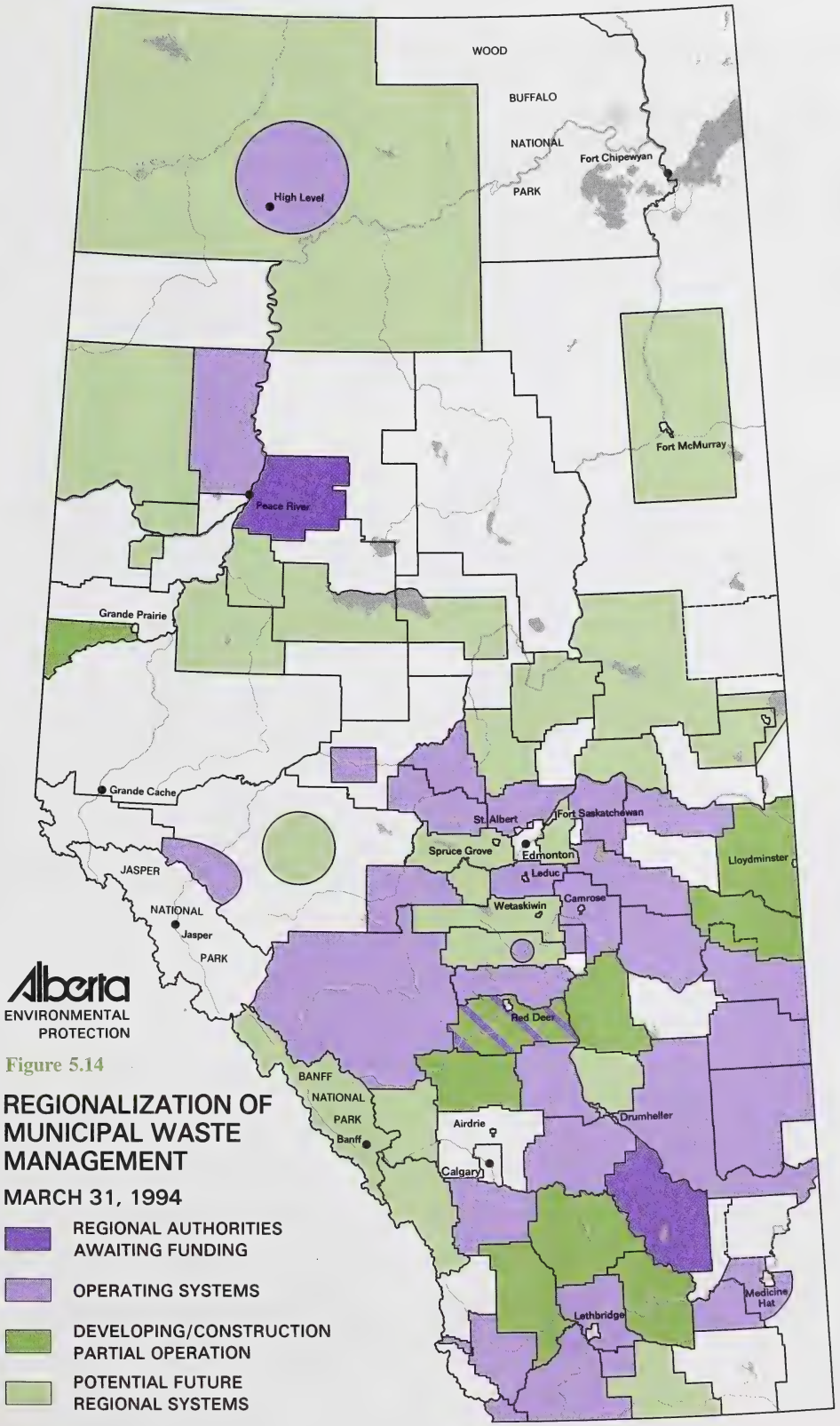


Figure 5.13 Composition of Municipal Solid Waste in Alberta, 1991.

Source: Action on Waste, 1992.


WOOD
BUFFALO
NATIONAL
PARK
Fort Chipewyan
High Level
Fort McMurray
Peace River
Grande Prairie
Grande Cache
JASPER
NATIONAL
PARK
Jasper
St. Albert
Fort Saskatchewan
Spruce Grove
Edmonton
Leduc
Lloydminster
Camrose
Wetaskiwin
Red Deer
BANFF
NATIONAL
PARK
Banff
Airdrie
Calgary
Drumheller
Medicine Hat
Lethbridge
Alberta
ENVIRONMENTAL
PROTECTION
Figure 5.14
REGIONALIZATION OF MUNICIPAL WASTE MANAGEMENT
MARCH 31, 1994
REGIONAL AUTHORITIES AWAITING FUNDING
OPERATING SYSTEMS
DEVELOPING/CONSTRUCTION PARTIAL OPERATION
POTENTIAL FUTURE REGIONAL SYSTEMS

B. WASTE MINIMIZATION

Waste minimization is increasingly being recognized as an important part of the waste management system. The term minimization includes activities that fall under the 4Rs hierarchy: reduce, reuse, recycle and recover. Minimizing waste at the source preserves natural resources, decreases the overall waste stream and lessens the impact on the environment. Promoting recycled products, participating in waste exchanges, composting, packaging reduction programs, encouraging effective economic instruments and providing consumer information are just some of the activities in Alberta.

Alberta has adopted the Canadian Council of Ministers of the Environment goal, which is to reduce waste to 50 percent of 1988 levels by the year 2000. A monitoring system is currently being developed to more accurately quantify wastes being diverted from landfills. These data will also feed into national systems, such as the National Solid Waste Inventory and the National Packaging Monitoring System. Based on available data, the waste disposal rate in Alberta has dropped from 1.15 tonnes per capita in 1988 to 0.98 tonnes per capita in 1992. Recycling programs are believed to have contributed to this drop.

C. RECYCLING

Recycling programs have become increasingly popular options for extending the life of landfills. There are over 100 municipal facilities throughout the province collecting recyclable materials. A breakdown of the main categories of materials actively being recovered and recycled, with a comparison of the recycling rates between 1987 and 1991, is shown in Figure 5.15.

Once predominantly a nonprofit driven activity, recycling is now evolving into effective partnerships between municipalities and business. Market-driven recycling programs can often be delivered at costs that are no greater than disposal. Although a range of materials is being recovered from the waste stream, paper, food and yard wastes (compostables), and construction and demolition wastes currently offer the greatest return and potential for recycling. The recycling of recoverable materials to date has largely been a voluntary one, and has contributed toward the reduction of waste disposed in landfills. Further action is required to stimulate markets for recyclables, to recycle more of the high volume waste streams, to involve industry in solutions and to build consumer awareness.

In addition to material being collected through municipal-based recycling activities (mostly paper, metal, glass, plastic and organics), some material is collected on a province-wide basis, such as beverage containers, tires, used oil, lead-acid batteries, pesticide containers and chlorofluorocarbons.

Beverage Containers

Under the *Environmental Protection and Enhancement Act*, beverage containers are designated as recyclable materials. Over 200 beverage container depots throughout the province provide convenient drop-off locations for consumers to return their beverage containers. In 1993, consumers returned over 500 million containers through this system, representing a 75 to 80 percent overall return rate.

To enhance the present return rates, a partnership has been developed among the participants in the beverage container recovery system, to educate consumers and promote the return of containers. Efforts are also underway to develop an industry-run organization that would be responsible for many aspects of the beverage container recovery system. Alberta beverage manufacturers are in the process of developing a common beverage container collection system, which will service all depots.

Tires

Every year, 2.5 million scrap tires are generated in the province. The Tire Recycling Management Board, formed in July 1992, is developing strategies to address health, safety and disposal issues surrounding scrap tires. The board is responsible for collecting and managing a $4 advance disposal surcharge paid on every new tire sold to ensure that revenues are in place to deal with past, present and future volumes of scrap tires. It is expected that close to 95 percent of Alberta's annual flow of scrap tires will be diverted from landfills through their use as fuel for cement plant kilns and in recycled rubber product development.

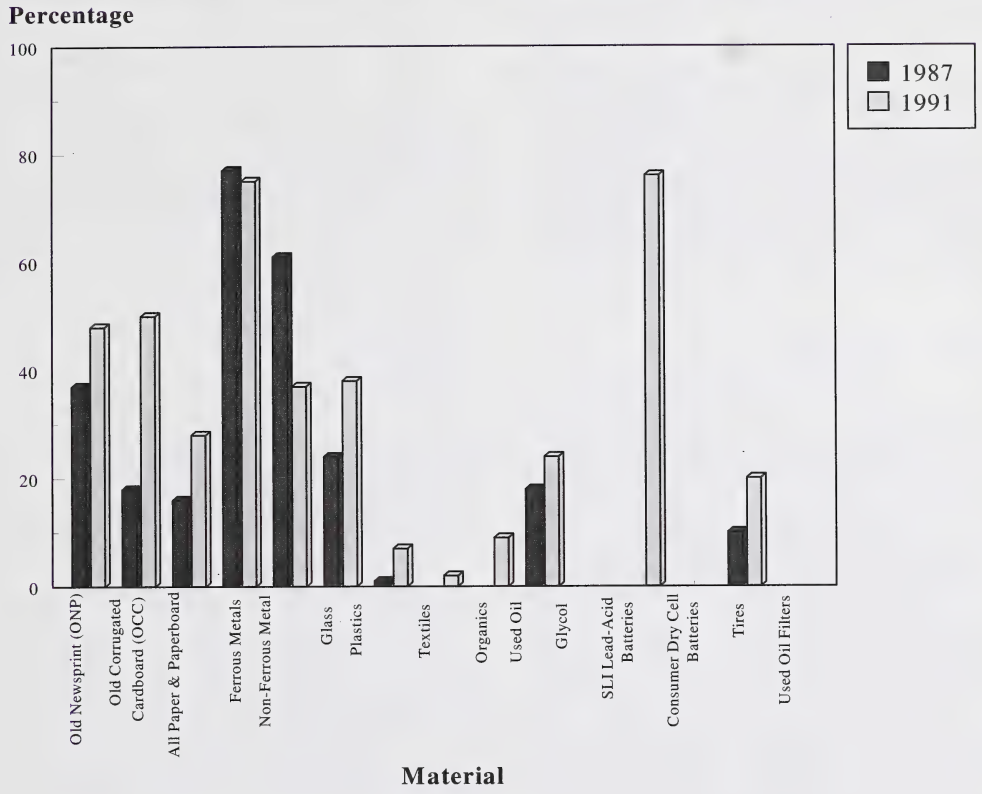


Figure 5.15 Recycling Rate Comparisons, 1987 and 1991.

Source: Alberta Environmental Protection, 1992.

Used Oil

Approximately 32 million litres of used oil are disposed of improperly in Alberta every year, posing a significant environmental protection challenge. Used oil from internal combustion engines is contaminated with a variety of substances, particularly heavy metals, that can be harmful to the environment. Alberta currently has three re-refiners of used engine, transmission, gearbox and hydraulic oils. Many municipalities offer collection sites at landfills or recycling depots, and some service stations provide collection services for a fee.

Six central Alberta communities are participating in the Alberta Used Oil Recycling Pilot Project, an oil industry-led effort to stem the flow of waste oil. Used oil, filters and plastic containers are being collected at participating bottle depots. Each depot is equipped with specially designed storage tanks and disposal bins to collect these used products for recycling. After the pilot project is completed by October 1994, the participants will evaluate the effectiveness of the centralized depot.

Lead-Acid Batteries

There are two main types of batteries: consumer dry cell and automotive SLI (starting, lighting and ignition) lead-acid batteries. The consumer dry cell batteries can contain small quantities of zinc, manganese dioxide, mercury, chromium, nickel, cadmium, silver and lithium. There is no recycling of these types of batteries and they generally end up in landfills, although some specialty firms may take them back for disposal.

The recycling rate for hazardous SLI lead-acid batteries, on the other hand, is 75 to 80 percent. Used lead-acid batteries are usually collected by scrap dealers, reduced to their component parts and sent to recyclers in Alberta, British Columbia and the United States. Over the past five years, the number of recyclers within Alberta has decreased from five firms to one. This decrease is due in large part to more stringent regulatory requirements and low lead prices. In spite of this decrease, the recycling rate for lead-acid batteries has remained high.

Pesticide Containers

Pesticides are used to control insects and other pests. Pesticides are useful chemicals when used properly, but can be potentially harmful if misused. This caution also applies to the containers in which pesticides are stored. To provide proper disposal alternatives for pesticide containers, Alberta Environmental Protection developed a pilot program in cooperation with rural municipalities to establish and operate pesticide container collection sites. More than 80 000 containers were collected in 1980, its first year of operation. Since then, approximately 100 permanent collection sites and 150 temporary collection sites have been established at local landfills or transfer stations. The ASWMC assumed the management of the program in 1990, with funding being provided by a $1 per container surcharge.

It is estimated that 75 percent of all containers entering Alberta are returned to the pesticide container collection sites. Metal containers are shredded, washed and recycled at IPSCO in Regina, Saskatchewan. Shredded plastic containers have been used for energy recovery or have been recycled into plastic lumber and fence posts. Plastic containers from 1993 were recycled into highway guard rail posts.

Chlorofluorocarbons

The *Environmental Protection and Enhancement Act* prohibits the release of ozone-depleting substances, such as chlorofluorocarbons (CFCs) into the atmosphere. These substances must be captured, contained and recycled, since no method of disposal has been developed to date. The recovered CFCs will continue to be used until alternative technologies are available.

D. SPECIAL WASTE

Alberta Special Waste Management Centre

The Alberta Special Waste Management Corporation (ASWMC) is an Alberta Crown Corporation established in April 1984. Based in Edmonton, the corporation is 40 percent owner of the Alberta Special Waste Management System. Through a joint venture with the private sector, the ASWMC owns and operates the system, which includes the Alberta Special Waste Treatment Centre near Swan Hills, and the collection and transportation network.

In addition to the Pesticide Container Collection Program, the ASWMC has organized the Household Toxic Round-Up and the Great Drug Round-Up, resulting in the recycling or safe treatment and disposal of potentially hazardous materials.

The Alberta Special Waste Treatment Centre (ASWTC) is permitted to treat all types of wastes generated in Alberta, with the exception of radioactive and explosive materials and biomedical wastes. The Alberta Government is considering a report submitted by the Natural Resources Conservation Board on the importation of hazardous waste. The materials currently accepted by the ASWTC fall into five major classifications. The quantities of waste that have been treated since its inception in 1987 to the end of 1993 are summarized in Table 5.18.

Table 5.18 Quantities of Waste Treated at Alberta Special Waste Treatment Centre.

	Tonnes
Inorganic Wastes	4 402
Organic Wastes	28 897
Metal Bearing Wastes	6 924
Household, Laboratory, etc.	1 636
Transformers	1 710

Note: Data are up to and including 1993.

Source: Alberta Special Waste Management Corporation.

E. ENERGY-RELATED WASTE

Effective September 1, 1993, responsibility for upstream oilfield waste treatment and disposal

facilities was consolidated at the Energy Resources Conservation Board. Prior to this, these facilities were jointly regulated by Alberta Environmental Protection and ERCB. As part of the regulatory consolidation, the ERCB required all existing oilfield waste processing and disposal facilities to re-apply for approval to operate. This requirement ensures complete documentation and allows checking that each facility meets the latest standards.

To define and apply more consistent standards, the ERCB joined facility operators, the oil and gas industry and other government agencies to develop a document entitled *Recommended Oilfield Waste Management Practices.*

The ERCB has long regulated wastes from drilling activity. After several years of research and discussion with industry and government, the ERCB released new drilling waste management and disposal requirements in March 1993. The most significant change is that all drilling waste must now be analysed to determine an appropriate disposal option. The long-term objective of the new regulations is to improve the management of the well drilling activity to reduce the amount of waste generated, encourage reuse of drilling materials and encourage the use of more environmentally benign drilling systems, muds and additives.

Work continued in 1993 and 1994 to update and more clearly explain regulatory requirements for deepwell injection and disposal facilities. Alberta has 7000 deep wells, which are used for injecting fluids for enhanced oil recovery, disposal of salt water normally produced with oil and gas and disposal of industrial waste such as process water from refineries.

As part of this effort, the ERCB worked closely with industry and government agencies for several years to develop a comprehensive deep well classification system that matches injection fluids to a specific well type. The classification relates to higher construction and operating standards for some types of disposal wells.

Contaminated sites are areas of the environment where the release of chemical substance(s) is predicted to cause or has actually caused an adverse effect on human or environmental health.

In Alberta, the common sources of contaminants include:

- accidental spills;
- failure of storage tanks, conduits and waste containment devices;
- unauthorized disposal of wastes on land;
- poorly managed land treatment of wastes;
- atmospheric deposition from industrial sites and transportation corridors;
- transport from an adjacent contaminated sites; and
- misuse of agrochemicals.

F. CONTAMINATED SITES

Two of the most significant initiatives that have been developed to address contaminated sites issues in Alberta were the Help End Landfill Pollution (HELP) and Management of Underground Storage Tanks (MUST) programs. The HELP program was introduced by the Minister of Environment in 1986 to inventory industrial landfills in Alberta. Almost 700 sites were inventoried under the program. The greatest number of industrial landfills were found to be associated with the oil and gas industry. Considerable numbers of contaminated sites have also been created through wood treatment, chemical manufacturing, mining activities and the abandonment of municipal and industrial landfills. Of the sites inventoried, 42 were found to be abandoned. Thirteen of these abandoned sites were identified as requiring further investigation. Canada Creosote Limited, a former wood preserving site located adjacent to the Bow River west of downtown Calgary, is the largest site. Detailed investigations have been conducted at all abandoned sites and a review of long-term remediation options is continuing.

The MUST program was put in place by the departments of Environment and Labour in 1988 to address the seriousness and increasing incidence of leaking petroleum storage tanks. Accomplishments of the program include: registration of 15 000 underground and above-ground tanks, preparation of clean-up guidelines for soil and groundwater at petroleum storage tank sites, a seven-year program of upgrading of storage tanks and making recommendations for changes to the Alberta Fire Code such as the certification of tank removers and installers.

KEY POINTS

- Landfilling is the most common method of disposal for municipal solid waste. Currently in Alberta, there are about 340 approved municipal landfills.
- Since 1976, over 220 smaller waste disposal sites have been replaced with 28 regional waste management systems. This restructuring has helped reduce complaints and concerns about pollution from waste management. There are several new regional landfill systems either in development or under consideration.
- Special wastes are collected by the Alberta Special Waste Management Corporation and treated by the Alberta Special Waste Treatment Centre. The latter facility has, to the end of 1993, treated over 43 500 tonnes of waste.
- The waste disposal rate in Alberta has dropped from 1.15 tonnes per capita in 1988 to 0.98 tonnes in 1992. This reduction is mainly a result of successful efforts to minimize waste.
- Recycling programs are becoming increasingly popular. Currently, over 100 municipal facilities in Alberta collect recyclable materials.
- In 1993, over 500 million beverage containers were returned to depots.
- The Tire Recycling Management Board is currently developing strategies to deal with the 2.4 million scrap tires generated annually in Alberta.
- The Alberta Used Oil Recycling Pilot Project is looking at the effectiveness of depots that collect waste oil.
- Consumer dry cell batteries are not being recycled. Automotive SLI batteries, however, have a 75 to 80 percent recycling rate.
- About 75 percent of used pesticide containers are being returned to collection sites and recycled.
- Presently, used chlorofluorocarbons are being captured and contained for recycling, since there is no method of disposal.
- New drilling waste management and disposal requirements have been developed by the Energy Resources Conservation Board. These requirements will ensure that all drilling waste is analysed to determine an appropriate disposal option.

FUTURE DIRECTIONS

- Alberta will maintain its commitment to reduce the amount of municipal solid waste by 50 percent by the year 2000.
- An interim goal of 25 percent reduction of 1988 municipal solid waste levels has been set for 1996.
- Strategies will continue to be developed to increase multi-stakeholder participation through awareness and partnerships.
- Efforts will continue to promote waste reduction at the source, while also facilitating improved markets for recyclable materials.

6.0 BIOTA

Alberta has a wide diversity of plant and animal species. Biodiversity refers to the range and variety of life on earth. Overall, the biodiversity on earth is decreasing as a result of species extinctions caused mainly by human activities. According to scientists, the loss of biodiversity is one of the three most serious global environmental threats (atmospheric change and the depletion of the layer are the others). The importance of conserving biodiversity is recognized worldwide and was the focus of the United Nations (UN) Convention on Biological Diversity in 1992, which Canada ratified. In response to the UN convention, a federal-provincial-territorial working group is developing a Canadian Biodiversity Strategy.

Alberta is strongly supportive of all efforts directed at the conservation of biodiversity. In Alberta, the conservation of biodiversity is linked with provincial initiatives such as the Forest Conservation Strategy and Special Places 2000. In addition, the Department of Environmental Protection is currently reviewing its approach to ecosystem management. Biodiversity is a key element in this review.

Traditionally, the management of biota has been species-oriented, focusing on those species of concern to humans (e.g., lodgepole pine for lumber, grass for cattle grazing and moose for hunting). It was assumed in many cases that what was good management for these species was good management for all. Today, however, management is moving toward a new model: the conservation of the communities and ecosystems that support individual species.

It should be noted that the following information is based on the old management approach. Although nongame species are monitored, the best data available are on game species, so these data are presented below.

A. PRESENT CONDITIONS

Plants

Table 6.1 contains general information on Alberta's vascular and nonvascular plants. In Alberta about 360 plant species, or a quarter of the native plants, are considered rare. Rare plants generally fall into four categories:

Table 6.1 Alberta's Vascular Plant, Moss and Fungi Biodiversity.

Group	Number of Species	Number of Genera	Number of Families	Number of Introduced Species	Number of Species Rare in Alberta	Number of Species Rare in Canada
Tree	28	11	6	1	3	0
Shrubs	162	65	29	7	19	1
Forbs	1222	378	92	220	217	81
Grasses	366	73	3	42	85	16
Total	1778	527	130	270	324	98
Mosses	601	157	67	N/A	N/A	N/A
Lichens	645	115	46	N/A	N/A	N/A
Fungi	454	128	34	N/A	N/A	N/A
Total	1700	400	147			
Total All Groups	**3478**	**927**	**277**			

Notes: Number of rare species is compiled from those species identified as rare in Packer and Bradley (1984) and Argus and Pryer (1990); also includes two species that are new to the province and thus considered rare. There is no specific legislation to protect rare plant species.

Source: Alberta Energy/Forestry, Lands and Wildlife, 1992.

- about 1 percent of Alberta's rare species have a widespread distribution, but are never abundant in terms of numbers (e.g., orchids), often due to special habitat requirements;
- about 84 percent are species that are widespread elsewhere, but reach the edge of their range in Alberta, and so have a small population here;
- about 10 percent are species found in localized, widely scattered populations; and
- about 5 percent of Alberta's rare species occur in a limited geographical area.

Of these rare species, some are threatened or endangered. For most of Alberta's rare plants, the scientific community is only beginning to gather the information required to determine which species are threatened or endangered.

Animals

There are approximately 90 species of mammals, 250 species of resident breeding birds, 50 species of fish and 18 species of reptiles and amphibians resident in Alberta. Ninety-five percent of these species are considered sustainable. Twenty-two species are at serious risk: 4 mammals, 11 birds, 2 fish, 2 reptiles and 3 amphibians (Table 6.2). The determination of whether a species is at serious risk is based on a combination of provincial assessment of the species' population and the status designation by the Committee on the Status of the Endangered Wildlife in Canada (COSEWIC). A more detailed assessment of the species at serious risk is shown in Appendix 2.

Table 6.2 Species at Serious Risk.

Mammals:	**Birds:**
Swift Fox	Baird's Sparrow
Wood Bison	Burrowing Owl
Woodland Caribou	Ferruginous Hawk
Yellow-cheeked Vole	Loggerhead Shrike
	Long-billed Curlew
Fish:	Mountain Plover
	Peregrine Falcon
Shortjaw Cisco	Piping Plover
Shorthead Sculpin	Trumpeter Swan
	Upland Sandpiper
Amphibians:	Whooping Crane
Great Plains Toad	**Reptiles:**
Long-toed Salamander	
Northern Leopard Frog	Short-horned Lizard
	Western Hognose Snake

Source: Fish and Wildlife Services, Alberta Environmental Protection.

Sport Fish

Of the 59 species of fish known to breed in Alberta, 17 are of interest to anglers. Overall, trout are the most popular sport fish. However, the walleye is increasing in popularity.

Lake whitefish, yellow perch and northern pike are close to being within 10 percent of the provincial targets for sustainable harvest. Lake whitefish occur at a density of 5.6 kilograms per hectare of water surface, yellow perch 2.2 kilograms per hectare and northern pike 2.2 kilograms per hectare.

Participation in Wildlife-Related Activities

The 1991 Survey on the Importance of Wildlife to Canadians reported that 94.7 percent of Albertans 15 years of age and over took part in a wide variety of wildlife-related activities (Table 6.3). This participation rate was the largest of the 10 provinces.

Since 1981, the date of a similar survey, participation in primary nonconsumptive, wildlife-related trips or outings has increased by 17 percent, while the population of Alberta increased by 16 percent. Over the same period, participation in hunting activities declined by over 28 percent.

Migratory Game Birds

Ducks

In Alberta, personnel from Alberta Environmental Protection's Fish and Wildlife Services and from Environment Canada's Canadian Wildlife Service conduct ground surveys of duck species throughout southern and central Alberta. These areas are also covered by aerial surveys flown by the United States Fish and Wildlife Service. The air and ground surveys provide data on the breeding bird populations and the number of ponds available for waterfowl. This information can also be used as an indicator of severity of drought as well as the loss (or gain) of wetlands.

Table 6.4 lists the estimated populations in 1993 of mallards and pintails (the two most sought-after species of ducks), plus the total populations of all dabbling ducks (including mallards and pintails) and all diving ducks in southern Alberta. It also lists the estimated number of ponds available to waterfowl. Figure 6.1 shows the relative long-term change in duck populations.

Geese

In Alberta, nesting populations are monitored through surveys of overwintering birds conducted by the United States Fish and Wildlife Service and State wildlife management agencies. Although these surveys do not provide information specifically on those birds that nest in Alberta, the data are related to the two populations from which Alberta birds are derived: the Hi-Line population and the Rocky Mountain population.

The Hi-Line population, according to the mid-winter survey of 1993-94, contained an estimated 164 000 birds. This total is 205 percent of the objective of 80 000 birds that has been set for the midwinter population. The Rocky Mountain population had 97 800 birds for 1993. This number is 163 percent of the objective of 60 000 birds set for the midwinter population.

Table 6.3 Participation by Alberta Residents in Wildlife-Related Activities in 1991.

	Number of Participants	Percent
Indirect Activities*	1 724 000	91.1
Residential Activities**	1 373 000	72.5
Primary Nonconsumptive Trips or Outings*	383 000	20.2
Incidental Wildlife Encounters during other Trips or Outings*	977 000	51.6
Hunting	134 000▾	7.1
Population of Alberta 15 years of age and over	**1 892 000**	**100.0**

* Indirect wildlife activities included watching films or television programs, or reading, visiting the zoo, game farm, aquarium or museum, purchasing art, or belonging to a wildlife organization.
** Residential wildlife activities were those that occurred around a residence or cottage and included watching, photographing, studying or feeding wildlife, or maintaining plants, shrubs or bird houses to provide food or shelter for wildlife.
* These were trips or outings whose primary purpose was to watch, photograph, study or feed wildlife.
* These were activities that occurred while on trips for business or pleasure whose primary purpose was other than to encounter wildlife. The activities included watching, photographing, feeding and studying wildlife.
▾ This study figure differs from the Wildlife Certificate sales for 1991-92 because the survey extrapolated to the larger population of Alberta residents from a sample of that population - with inherent surveying and sampling errors. The Wildlife Certificate sales figure is the exact number of sales of Wildlife Certificates to Alberta residents and visitors to Alberta for a period (fiscal year) that is not exactly the same as the year used by the Environment Canada survey (calendar year).

Source: Environment Canada, 1993.

Riparian Habitat

Riparian (riverbank) poplar forests are extremely important for wildlife, recreation and Native people. In 1991 the World Wildlife Fund and Alberta Environmental Protection compared the density of riparian poplar forests in southern Alberta from the 1950s to the 1980s (Figure 6.2 shows the density for the 1980s). They found that there was no significant change in density. There may, however, be decreases in riparian habitat on specific reaches that could not be detected on a large scale. Other river reaches have actually seen an increase in riparian habitat.

Table 6.4 Estimated Duck Populations in Southern Alberta.

Species	1993 Breeding Population (000s)
Mallard	753.9
Pintail	372.5
Dabbling Ducks	2862.8
Diving Ducks	580.3
Ponds	689.7

Source: Fish and Wildlife Services, Alberta Environmental Protection.

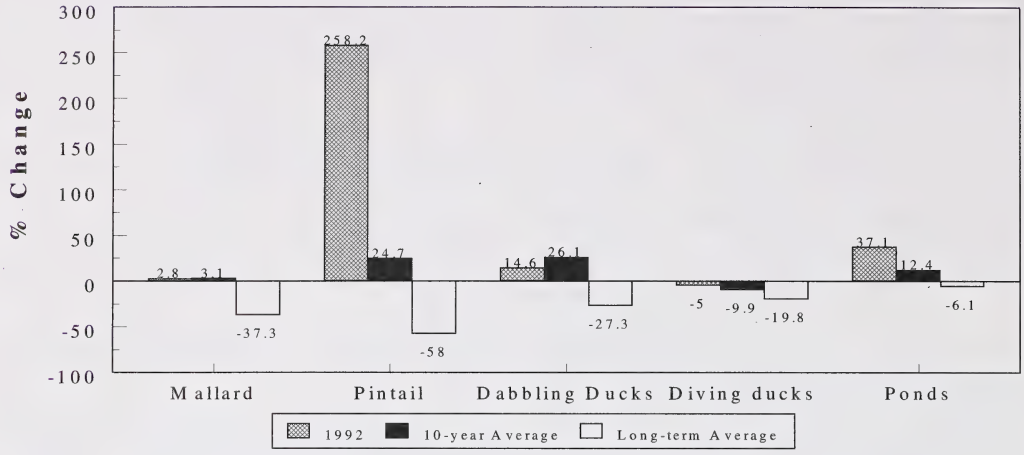


Figure 6.1 Relative Change in Duck Populations in Southern Alberta.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

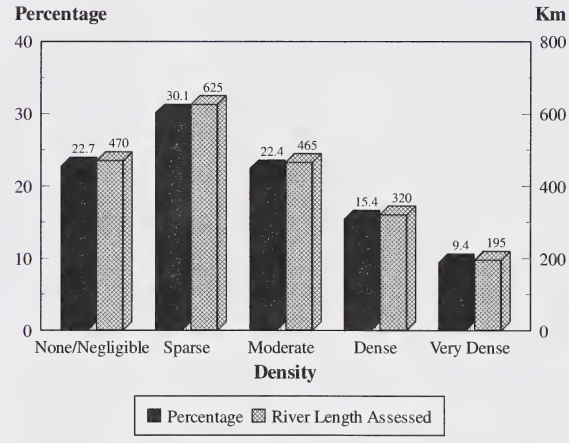


Figure 6.2 Riparian Poplar Density in Southern Alberta in the 1980s.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

B. STRESSES

Utilization of fisheries and wildlife resources can create stresses on populations if not managed according to sustainable use principles. Programs are in place to allow recreational and commercial uses of these renewable resources without affecting their long-term health and viability.

Recreational Fishing

The results of a 1990 survey of sportfishing in Alberta confirmed that sportfishing is a significant form of outdoor recreation. Sportfishing also has a major impact on the fisheries resource.

In 1990, anglers caught an estimated 13.7 million fish of all species and retained 5.1 million of them. In total, these fish weighed approximately 3.1 million kilograms. Resident anglers caught 99 percent of the number of fish harvested.

Perch, northern pike, trout and walleye were the most widely taken species, accounting for 90 percent of the catch and 88 percent of the harvest. On average, 22 fish were retained per active adult angler. Of the 22 fish, there were 10 perch, 5 northern pike, 3 trout, 2 walleye and 2 of other species. Anglers, practising voluntary catch-and-release fishing or complying with size-limit regulations, released 62.5 percent of all fish caught. Over 40 percent of the anglers indicated they voluntarily practised catch-and-release fishing.

Angling in Alberta is a major recreational activity. An estimated 327 000 anglers (including 98 000 children under the age of 16, who do not require fishing licences, and excluding seniors) fished a total of about 3.3 million days in 1990. On the average, each angler spent 14.6 days fishing. The quality of fishing in 1990 was rated as good to excellent by 53 percent of the anglers; 27 percent rated fishing as fair, and 19 percent rated the quality as poor.

Sixty-six percent of the anglers stated the quality of the fishery had declined between 1985 and 1990. Overfishing was rated as an important reason for the decline.

Sportfishing Licence Sales

People 16 through 64 years of age who wish to sportfish in Alberta (excluding certain Natives) must hold a Sportfishing Licence. The annual sale of sportfishing licences has been in decline since it reached an all-time high of just over 359 000 in 1986-87. In 1992-93, over 240 000 sportfishing licences were sold (Figure 6.3).

Commercial Fishing

In 1992-93, over 1700 licensed commercial fishermen participated in 113 commercial fisheries on 86 lakes. Figure 6.4 lists the weight and value of the harvest for the last three years. The harvest value is based on landed value, and does not include any value-added processing in Alberta, or second payments to fishermen who deliver to the Freshwater Fish Marketing Corporation.

Wildlife Certificate Sales

Each person wishing to hunt in Alberta (excluding certain Natives) must purchase a Wildlife Certificate. This certificate entitles the holder to purchase game bird and big game hunting licences. With a few exceptions (Figure 6.5), Wildlife Certificate sales have been in steady decline since 1980-81 when they reached an all-time high of just over 166 000. In 1992-93, over 112 000 Wildlife Certificates were sold.

Game Harvest

With the help of volunteers, Alberta Environmental Protection obtains harvest information by conducting telephone surveys of a sample of resident hunters. Tables 6.5 and 6.6 list the estimated harvest of big game and game birds based on these surveys.

Fur Harvest

The value of wild fur harvested in 1993-94 by 4200 Alberta trappers was $3.2 million. Figure 6.6 shows the changes in this annual value since 1986-87, when fur production was $10.2 million.

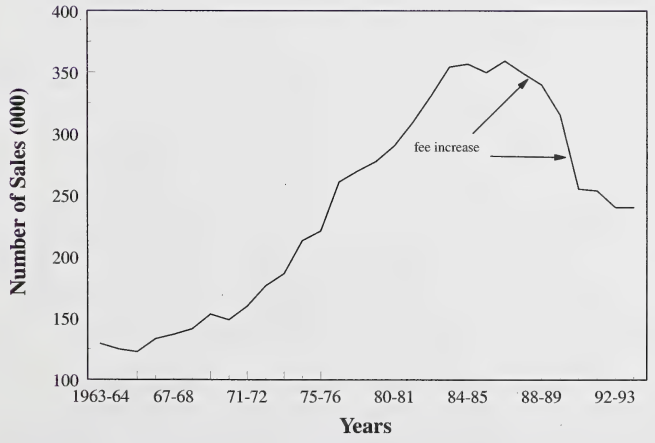


Figure 6.3 Alberta's Sportfishing Licence Sales, 1963 to 1993.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

C. ACTIONS

The following section discusses some of the wildlife management and conservation programs in Alberta that help mitigate the stresses on animal populations.

Watchable Wildlife

The Watchable Wildlife Program was designed by Alberta Environmental Protection to increase public awareness, understanding and enjoyment of Alberta's wildlife heritage. The program guides the

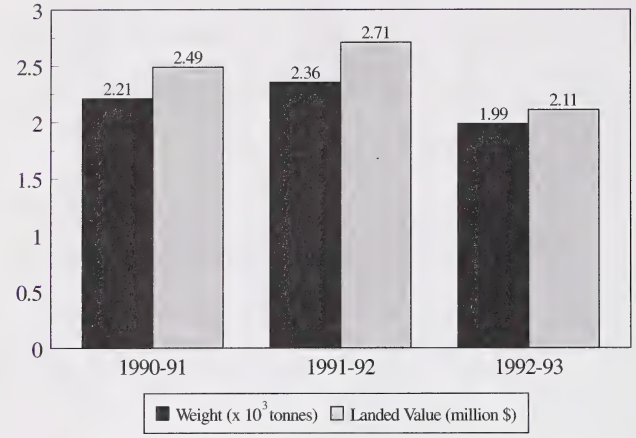


Figure 6.4 Weight and Value of Alberta's Commercial Fish Harvest, 1990 to 1993.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

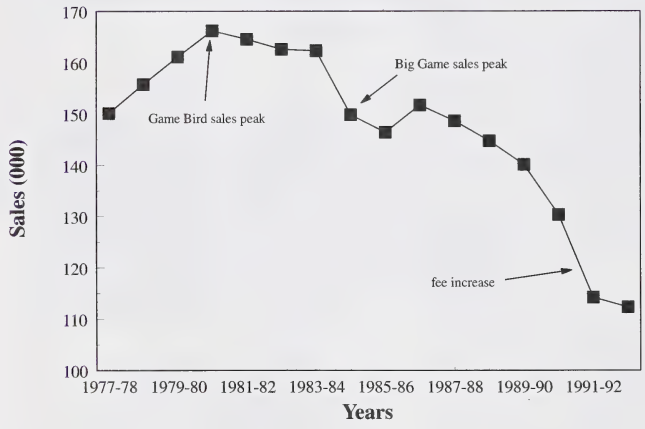


Figure 6.5 Wildlife Certificate Sales, 1977 to 1993.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

identification and management of wildlife-viewing sites and promotes wildlife-viewing ethics. Wildlife-viewing sites include selected national, provincial and municipal parks, natural areas, wildlife sanctuaries, forest recreation areas and Buck for Wildlife project areas. The program has published the *Alberta Wildlife Viewing Guide* and the *Directory of References for Alberta's Watchable Wildlife*, both of which are available for sale to the public.

Fishing, Hunting and Trapping Regulations

Alberta Environmental Protection's Fish and Wildlife Service enforces fishing, hunting and trapping regulations that are designed to allocate and conserve these valuable resources under authority of the federal *Fisheries Act* and the *Wildlife Act*. These regulations are reviewed annually in consultation with the public. Alberta Environmental Protection publishes summaries of the regulations annually in the *Guide to Sportfishing*, the *Guide to Hunting* and the *Guide to Trapping*. Fees from the sale of fishing and hunting licences fund various conservation programs through the Fish and Wildlife Trust Fund.

Fish Stocking

Alberta Environmental Protection hatches and raises various species of fish for stocking lakes and streams. This stocking provides fish for recreational fishing and maintains natural populations. Most of the hatchery stock, which had been destroyed in 1989 to eradicate an infection of the *pancreatic necrosis* virus in the hatcheries, has now been replenished.

In total, 3.2 million trout (rainbow, cutthroat, brown and brook) were stocked into 203 water bodies in 1992-93. This figure is higher than the 2.7 million trout stocked in 1991-92. An additional 16 lakes and reservoirs were stocked in 1992-93 with 22.9 million walleye fry and

Table 6.5 Estimated Numbers of Big Game Harvested by Residents, 1990 to 1992.

Species	Antlered			Antlerless			TOTAL		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
White-tailed Deer	20 191	21 829	19 499	6 405	8 058	6 281	26 596	29 887	25 780
Mule Deer	10 114	9 309	9 051	5 039	5 077	6 540	15 153	14 386	15 591
Moose	10 504	8 352	6 573	1 292	2 111	1 787	11 796	10 463	8 360
Elk	1 502	1 482	1 360	490	643	695	1 992	2 125	2 055
Antelope	1 984	696	713	1 648	570	1 226	3 632	1 266	1 939
Bighorn Sheep	190	183	229	85	123	151	275	306	380
Black Sheep	615	912	NA	247	222	NA	862	1 134	NA
Cougar	27	30	27	17	10	9	44	40	36
Grizzly Bear	12	6	17	7	2	3	19	8	20

Note: NA = Not Available

Source: Fish and Wildlife Services, Alberta Environmental Protection.

Table 6.6 Estimated Game Bird Harvest, 1988 to 1992.

Species	1988	1989	1990	1991	1992
Ducks	175 576	237 293	178 875	174 531	105 044
Geese	104 645	128 492	98 735	131 249	86 064
Gray Partridge	71 169	65 957	47 316	41 122	22 407
Ruffed Grouse	355 190	282 453	142 463	131 586	46 074
Sharp-tailed Grouse	54 025	39 960	35 469	43 471	12 062
Spruce Grouse	38 933	23 783	16 674	16 031	6 541
Blue Grouse	1 462	1 853	656	253	155
Sage Grouse	452	104	NA	NA	NA
Ptarmigan	395	169	210	NA	NA
Pheasant	54 025	39 374	34 319	33 464	31 841

Source: Fish and Wildlife Services, Alberta Environmental Protection.

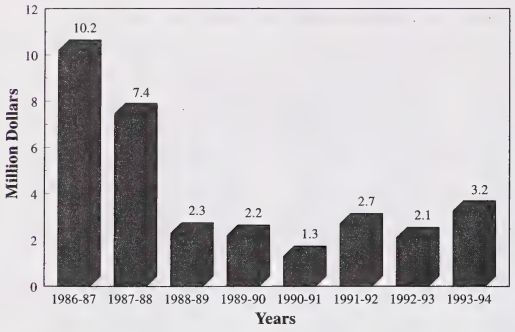


Figure 6.6 Wild Fur Production, 1986 to 1993.

Source: Fish and Wildlife Services, Alberta Environmental Protection.

1.8 million walleye fingerlings. As well, five lakes were stocked with yellow perch and one lake with northern pike.

Alberta Fish and Wildlife Trust Fund

The Fish and Wildlife Trust Fund was established under the *Wildlife Act* to provide financing for programs that protect and enhance fish and wildlife species and their habitats. It also funds programs to prevent wildlife damage and to promote the development and use of humane traps. Each of the following programs under the fund are financed by portions of fees from licence sales, as well as tax deductible donations.

Buck for Wildlife

The Buck for Wildlife Program funds projects that retain, enhance or create fish and wildlife habitat. During 1993-94, the program supported 180 wildlife and fish habitat projects. Of these, 42 involved funding through grants to various nongovernment organizations. The 180 projects protected and enhanced over 35 000 hectares of wildlife habitat, and over 8600 hectares and 100 kilometres of fish habitat.

Wildlife Habitat Development Projects

Wildlife Habitat Development Projects are funded by $7 from the sale of each Resource Development Stamp (sold with the Wildlife Certificate), $10 from the sale of each pheasant licence and $3 from the sale of each hunting draw application. In 1993-94, the fund financed 37 wildlife habitat development projects.

Fisheries Habitat Development Projects

These projects are funded by $5 from the sale of each Sportfishing Licence. In 1993-94, the fund financed 48 new or continuing fish habitat development projects, 12 fish habitat development grant projects and the maintenance of many completed habitat development projects throughout the province.

Fisheries Management Enhancement Program

This program funds efforts to enhance fish production and protection to meet the demands of recreational fishing. The program is financed by $5 from the sale of each Sportfishing Licence. In 1993-94, the program supported 53 projects. Of these, nongovernment organizations undertook 14.

Wildlife Management Enhancement Program

The Wildlife Management Enhancement Program funds programs and projects that ensure the well-being and perpetuation of wildlife populations. A portion of the 1991 fee increase of 10 percent to all hunting licences funds the program. In 1993-94, 22 projects were carried out.

North American Waterfowl Management Plan

Some information on the NAWMP has already been provided in Section 5.4C. Looking ahead over the scheduled 15 years of NAWMP activities in Alberta, approximately 1.2 million hectares have been projected for habitat conservation work. A portion of the 1991 fee increase of 10 percent to all hunting licences finances the Alberta segment of funding.

Report A Poacher Program

The Report A Poacher Program provides Albertans with the opportunity to report suspected violations of fish, wildlife and environmental legislation. A toll-free number (1-800-642-3800) is operated 24 hours a day. One dollar from the sale of each recreational hunting licence (except the pheasant licence) funds the program. Rewards of up to $1000 are paid for information that results in a Fish and Wildlife Officer laying a charge. In

1993-94, the Report A Poacher Program received 3728 calls. Of these, 6 percent were eligible for a reward.

Wildlife Support Program

The Wildlife Support Program provides funding for programs to prevent damage or loss caused by waterfowl, and for injury or death of livestock resulting from the use of a weapon during an open hunting season. The program is financed by $9.02 from the sale of each Wildlife Certificate. The objectives of the Wildlife Support Program were met through the following programs:

- The Waterfowl Damage Prevention Program was jointly conducted by Alberta Environmental Protection and Environment Canada during 1993-94. During 1993, program field crews responded to 427 damage complaints and provided assistance to farmers to reduce losses on 590 quarter sections of cropland. Grain producers used scare cannons to deal with 249 potential damage cases on 379 quarter sections of cropland. Total program expenditures were cost-shared between Alberta Environmental Protection and Environment Canada.

- The Shot Livestock Program provides compensation to livestock producers who had livestock injured or killed by a weapon during an open hunting season. In 1993-94, there were 14 compensation claims processed, in total.

- The Humane Trapping Program funds the development and use of humane trapping systems. The program supports research, trap testing, trap replacement and education of trappers and the public. The fund is financed by the revenue from fur royalties.

During 1993-94, financial assistance was provided to the following agencies:

- the Fur Institute of Canada for humane trap research and education;

- the Alberta Trappers Association to assist in presenting public information and educational programs; and

- Alberta Environmental Protection to fund Standard Trapper Education courses.

Endangered Species Legislation

In Alberta, legal protection for endangered species is provided by the *Wildlife Act* and regulations. The Act and regulations describe those species considered to be endangered and prohibits their killing, hunting or harassment, and protects their nests and dens from disturbance.

Recovery of Nationally Endangered Wildlife (RENEW)

This program was established by the Council of Canadian Wildlife Ministers in 1988. The RENEW program is a national strategy for the recovery of endangered species and involves an organization (the RENEW Committee) to apply it. The program coordinates federal, provincial and territorial governments, and nongovernmental organizations. The objectives are to protect endangered and threatened species, to reintroduce species that no longer occur in Canada and to help the recovery of threatened or endangered species. Presently, the program covers terrestrial vertebrates: mammals, birds, reptiles and amphibians.

The goal of RENEW is to appoint recovery teams to prepare national recovery plans for threatened and endangered species in Canada. These plans aim to remove species from threatened and endangered status. To date, recovery plans have been approved for the following Alberta species:

COSEWIC status: endangered--

- Burrowing Owl
- Peregrine Falcon
- Whooping Crane

COSEWIC status: threatened--

- Baird's Sparrow
- Ferruginous Hawk
- Loggerhead Shrike
- Piping Plover
- Woodland Caribou

COSEWIC status: extirpated--

- Greater Prairie Chicken

Actions are currently underway on all of these recovery plans. Each plan has its own chairperson, goal statement and objectives. Alberta is represented on 14 of the National Recovery Teams created under RENEW.

Swift Fox Reintroduction

The swift fox is currently on the Alberta list of species at serious risk; the wild population is estimated at 150 animals. The swift fox reintroduction is a continuing, cooperative effort between Alberta Environmental Protection, the Canadian Wildlife Service and the Saskatchewan government. In May 1993, the results of a reintroduction feasibility study were published. Based on these results, a five-year reintroduction program for the swift fox is underway. The goal of the program is to restore this species to its historic habitat in the Canadian prairies. In March 1994, a National Recovery Plan was submitted to RENEW for approval.

Peregrine Falcon Reintroduction

The year 1994 was the third year of a five-year reintroduction program for the peregrine falcon. The program aims to re-establish the falcon in its historic habitat in southern Alberta. A total of 90 falcon chicks were released from river cliffs in southern Alberta throughout 1992 and 1993. Wild nests throughout the province were monitored and captive-raised "foster" chicks were added to the nests where required, to boost natural reproduction.

Burrowing Owl Survey

In 1993, a population survey of burrowing owls was conducted to collect benchmark data to evaluate population trends. A previous survey in 1991 suggested a population decline. The population trend surveys were repeated in 1994, and a comprehensive population census was initiated.

Woodland Caribou

Caribou populations appear to have been steadily declining since the early 20th century. In Alberta, caribou habitat has been under pressure from industrial activity. A monitoring and research program for caribou in northern Alberta is currently underway. The program is being conducted in cooperation with universities and the forestry and petroleum industries. In addition, a provincial caribou management strategy is being developed by a multistakeholder committee.

Since July 1991, government and industry have devoted considerable attention to Alberta's caribou population. In 1991, the Alberta Energy and then Alberta Forestry, Lands and Wildlife developed A Procedural Guide for Oil and Gas Activity on Caribou Range, which states that development activities can occur on caribou range provided that the integrity of the caribou habitat is maintained. It also outlines five principles to guide integrated resource management decisions:

- forewarn industry;
- plan and coordinate development;
- cooperation between government and industry;
- maintain a flexible approach; and
- manage access.

This cooperative industry and government approach sparked the formation of five caribou standing committees. Each is working to integrate caribou conservation and resource development within specific regions or caribou ranges of Alberta. Most notable among these is the Northeast Region Standing Committee on Woodland Caribou. This diverse collection of industry and government representatives has pooled resources and garnered financial support from conservation funds to focus its initial efforts on research. The information will lead to a better understanding of caribou biology, caribou populations, and the impacts of resource development disturbances so that practical and effective general land use guidelines can be developed.

KEY POINTS

- About a quarter of Alberta's native plant species are considered rare. Some are threatened or endangered, but there is insufficient information to designate plants appropriately.
- Ninety-five percent of Alberta's population of mammals, birds, fish, reptiles and amphibian considered sustainable. Twenty-two species are at serious risk.
- Proportionally, more Albertans participate in wildlife-related activities than in any other province in Canada.
- Because hunting and fishing have significant impacts on the wildlife resource, these activities are carefully managed.
- Fish stocking maintains some natural fish populations in Alberta and provides fish for sportfishing.
- The Alberta Fish and Wildlife Trust Fund continues to fund a significant number of programs that protect wildlife species and their habitats.
- There are some national and provincial programs that aim to protect and, in some cases, reintroduce endangered wildlife species.

FUTURE DIRECTIONS

- Data based on the ecosystem management approach are needed, so that whole ecosystems are considered, and not just individual species.
- Action is required on the conservation of Alberta's biodiversity.
- Further work is needed on indicators that measure the loss of natural habitat and the impacts such losses have on biota.
- The quality of data for nongame species needs to be improved.

7.0 CONCLUSION

The quality of Alberta's environment is among the best in Canada. Air quality and drinking water quality are closely monitored and continue to exceed established guidelines. Because it is recognized that land use activities and various industrial activities have impacts on water, land-based resources and wildlife, actions are being taken to reduce these impacts. Wastes, generated by all sectors of society, are also being managed to reduce their impact on the environment.

As residents of Alberta, we all play a critical role in protecting the environment. Collectively, what we do in our day-to-day lives is significant; all our little actions add up to big ones. These actions can contribute to the degradation of the environment, or they can help to protect it. As individuals, we can modify our lifestyles and our attitudes toward the environment. We can make responsible choices as consumers, choices that can influence industry and business to produce environmentally safe products. No single group can assume responsibility for a healthy environment; individuals, business, industry and government must share the task. Everyone must work together as custodians of the environment; we all have shared responsibility.

In changing attitudes about the environment, education is critical. It is essential that future generations have more of an environmental awareness than present generations have. Alberta SOE reports can be a part of this change in focus. They have the potential to be important educational tools.

Environmental education should not stop at the school system. Education in environmental issues for the general public is also very important. As part of this, Albertans need access to information about the environmental issues in the province. The Alberta SOE report series is one way to provide meaningful environmental information. The SOE reporting aims to improve, within the public and among experts, the understanding of the state of the environment and how the environment changes over time in response to human activities. It is designed as an information guide for all those who are interested in the environment—including members of the public, government, industry and business.

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GLOSSARY

Ambient Concentration: Surrounding or background concentration.

Annual Allowable Cut (AAC): The level of timber harvest that is permitted in Alberta each year. The AAC is determined for coniferous and deciduous tree species using timber volume, growth and yield information.

Aquifer: A layer of rock or soil that is able to hold or transmit water.

Biochemical Oxygen Demand: The amount of needed to decompose material by microorganisms (as measured in a standard laboratory test).

Biodiversity: The variety of life on Earth. It describes the variety of *ecosystems* and species around the world and the genetic variation found within and between species.

Biomedical Waste: Pathological waste, infectious waste, hazardous waste, and other waste generated in health care facilities and laboratories that requires special handling.

Bog: A type of wetland characterized by the accumulation of peat and by relatively stable water levels. The water in a bog comes primarily from rainfall, is low in nutrients, and is acidic. Vegetation consists primarily of Sphagnum mosses, leathery leaved shrubs and some stunted black spruce or tamarack trees.

Brunisolic Soils: Brownish-coloured soils that develop in well to imperfectly drained conditions and are found in a wide range of environments (e.g., mixed forest, shrublands, grasslands, heath and tundra).

Chernozemic Soils: Soils that are black and rich in material and that develop from the decomposition of grassland vegetation. Chernozemic soils are characteristic of continental interiors and are important agricultural soils.

Chlorofluorocarbons (CFCs): Gaseous synthetic substances made of chlorine, fluorine, carbon, and sometimes hydrogen. They have been used in refrigerators, aerosols, cleaning solvents, and in the manufacture of plastic foam. CFCs tend to reside in the atmosphere for very long periods. They are suspected of causing depletion in the stratosphere, and are strong *greenhouse gases*.

Chlorophyll: One of two green plant pigments, chlorophyll a and chlorophyll b. Chlorophyll molecules absorb light as the first step in the light reactions of *photosynthesis*.

Chronic: Refers to a condition (usually a disease) that is constant or lasting.

Coulee: A deep ravine.

Cubic Decametre: A measure of volume. One cubic decametre is equal to the volume of a cube that is 10m x 10m x 10m.

Deciduous: Refers to plants that lose their leaves annually.

Disposition: See *Land Disposition.*

Ecological Integrity: Refers to the degree to which an *ecosystem* is intact.

Ecosystem: A biological community of living organisms and their nonliving environment. Ecosystems are composed of air, land, water, and living organisms, including humans. In an ecosystem, nutrients pass between the different organisms in definite pathways.

Edge Effect: The boundary between two different types of habitat (e.g., a forest and a meadow) is called an "edge." Large ungulates (e.g., elk, deer) forage on undergrowth, specifically plants such as willow and dogwood. The edge between forest habitat and open areas contains more of this forage than the forest itself. This is referred to as the "edge effect."

Effluent: A liquid waste material that is a by-product of human activity (e.g., liquid industrial discharge or sewage), which may be discharged into *ecosystems*.

Endangered: As defined by the Committee on the Status of Endangered Wildlife in Canada, an endangered species is one that is at risk of imminent *extinction* or *extirpation* throughout all or a significant portion of its Canadian range. See also *threatened*, and *vulnerable*.

Environmental Indicator: See *Indicator*.

Environmental Protection and Enhancement Act (EPEA): One of the most important examples of environmental legislation in the province is the *Environmental Protection and Enhancement Act* (EPEA), which came into force September 1, 1993. The Act brings together a number of acts into one package. In this way, it looks at the protection of air, land and water in an integrated manner. The Act spells out the environmental responsibilities of those who operate or propose developments, including a legislated process for environmental assessments of projects. Providing opportunities for public involvement in decisions that affect the environment is another important part of the Act. Increased access to environmental information and public involvement in the Environmental Assessment Process are some of these opportunities.

Euphotic: The upper layer or zone of a water body as defined by light penetration; the upper limit is the water surface, the lower limit is the depth to which sufficient light for photosynthesis can penetrate.

Exotic Species: Any species that enters an *ecosystem* beyond its natural range through deliberate or accidental introduction by humans. Includes those species that have been genetically modified through biotechnology.

Extinct: As defined by the Committee on the Status of Endangered Wildlife in Canada, an extinct species is one that no longer exists anywhere on the planet. See also *extirpated*, *endangered*, *threatened*, and *vulnerable*.

Extirpated: As defined by the Committee on the Status of Endangered Wildlife in Canada, an extirpated species is one that no longer exists in the wild in Canada, but occurs elsewhere. See also *extinct*, *endangered*, *threatened*, and *vulnerable*.

Fecal Coliform Bacteria: A group of bacteria that mainly inhabits the intestinal tracts of humans and other warm-blooded animals. The coliform group is commonly used as an *indicator* of water quality because exposure to these bacteria in drinking water can cause diseases such as cholera.

Fen: A type of wetland characterized by the accumulation of peat and by relatively stable water levels. The water in a fen comes primarily from ground water, is relatively nutrient rich and is of moderate pH. Vegetration is usually sedges, grasses and shrubs, and there may be cover of black spruce and tamarack trees.

Glacial Till: A type of sediment that results when glaciers erode and crush rock debris.

Green Area: The Green Area is an administrative classification of public land in Alberta. It consists of the non-settled forest lands and covers 53 percent of the total area of the province. Public lands in the Green Area are managed primarily for forest production, watershed protection, fish and wildlife management, recreation and other multiple uses.

Greenhouse Gases: A gas which has the capability to absorb infrared radiation in the atmosphere and reflect it back to earth, thus contributing to global warming (see **Carbon Dioxide and Other Greenhouse Gases**, p. 19, for a discussion of the greenhouse effect).

Gullies: Channels in the land formed by the erosive power of water.

Herbicide: A substance toxic to plants and used to destroy unwanted vegetation.

Indicator: A measure that, tracked over time, provides information on trends in the condition of a phenomenon. Hence, **environmental indicators** describe trends in the condition of the environment.

Kraft Pulp Mill: A type of pulp mill that produces coarse, brown paper of great strength. Kraft paper is commonly used to produce corrugated cardboard or grocery bags.

Land Disposition: A land disposition is a temporary (i.e., lease, license, permit or letter of authority) or permanent (i.e., land sale) authority for surface activities, issued persuant to the *Public Lands Act.*

Luvisolic Soils: These type of soils occur on the plains under deciduous, mixed and coniferous forest. They are light in colour and develop in well to imperfectly drained sites under forest vegetation.

Marshlands: Low-lying lands that are flooded in wet weather, and usually watery at all times.

Morainal Terrain: Land characterized by hummocks of debris that have been deposited by a glacier.

Non-Point Source: Source of pollution in which pollutants are discharged over a widespread area or from a number of sources rather than from distinct, identifiable sources. See also *point source*.

Nonviable: Not able to live; pertaining to plants and animals.

Organic Compound: One that contains carbon in its molecular structure.

Outwash: Material that is carried from a glacier by water and deposited beyond a moraine (see *Morainal Terrain*).

Pathogen: A disease-causing microorganism, including viruses and many bacteria and fungi.

Peat: Accumulated dead plant material that has remained incompletely decomposed due to the lack of oxygen that is the result of the presence of water. It often forms a layer of many feet deep.

Petajoule: A joule is a unit of energy equal to 0.24 calories. One petajoule equals one thousand million (10^{15}) joules.

pH: A numerical expression of the concentration of hydrogen ions in solution--pH 0 to 6.9 is acidic, pH 7 is neutral, and pH 7.1 to 14 is basic or alkaline.

Photochemical Smog: A form of atmospheric pollution that produces a brownish yellow haze, especially over urban areas. Ground-level is a major component (see **Ground-Level Ozone**, p. 15).

Photosynthesis: The chemical process by which green plants make compounds from carbon dioxide and water in the presence of sunlight. The other products of this process are water and .

Point Source: A source of pollution that is distinct and identifiable (e.g., smokestacks from industrial plants and outfall pipes from municipal sewage treatment plants). See also *non-point source*.

Population Density: A measure that describes the number of people per unit of land.

Precipitation: All liquid and solid forms of water that are deposited from the atmosphere (e.g., rain, snow, hail, dew and frost).

Rangeland: Areas of land, usually not adapted to cultivation, covered with native grasses and other forage plants and best suited for grazing by domestic and wild animals.

Reclamation Certificate: A document that certifies an activity that has resulted in land disturbance (e.g., an oil well) has met the requirements for conservation and reclamation under EPEA.

Reserves: A term used to describe the amounts of mineral resources located beneath the land surface. **Established reserves** are those reserves that can be recovered under current technology and present (and anticipated) economic conditions. They have been specifically proven by drilling, testing or production, or have been interpreted to exist with reasonable certainty from geological, geophysical or similar information.

Respiration: In animals and plants, the process by which substances are broken down with the release of energy, which is used by the organism. In most cases, respiration requires and produces carbon dioxide. The exchange of and carbon dioxide gases takes place in the respiratory system, which includes the lungs in air-breathing vertebrates.

Seismic Exploration: A method of exploration for mineral resources that involves the detonation of explosive charges below the land surface. The resulting soundwaves are recorded on a "geophone" and are used to produce a subsurface map.

Shelterbelts: Rows of trees and shrubs, generally running perpendicular to the prevailing winds, that protect adjacent crops from erosion.

Stratosphere: The second lowest layer of the atmosphere, which runs from about 7 km to 50 km above the ground. The temperature in this layer stays approximately constant.

Threatened: As defined by the Committee on the Status of Endangered Wildlife in Canada, a threatened species is one that is likely to become *endangered* in Canada if the factors affecting its vulnerability are not reversed. See also *extinct*, *extirpated*, *endangered*, and *vulnerable*.

Tillage: Mechanical, soil-stirring actions for the purpose of nurturing crops. Examples include soil aeration, weed control, managing crop residue and incorporating fertilizers.

Understorey Growth: Refers to those plants that grow beneath the cover of the forest canopy.

Viable: Of plants and animals, able to live and grow.

Vulnerable: As defined by the Committee on the Status of Endangered Wildlife in Canada, a vulnerable species is one that is at risk because of low or declining numbers, small range, or for some other reason, but is not a *threatened* species. See also *extinct*, *extirpated*, *endangered*, and *threatened*.

White Area: An administrative classification of public land, the White Area is the settled region of the province; it covers nearly one-third of the total area of Alberta. Available public lands in this region that are suitable for settlement and are not required for other uses can be applied for, pursuant to the *Public Lands Act*.

APPENDIX 1 - THE NATURAL REGIONS OF ALBERTA

A recently developed classification system describes Alberta's natural landscapes. This system combines the former ecoregions and natural regions concepts, and uses similarities in landforms, hydrology, geology, soils, climate, plants and animals to classify natural landscapes. The largest units are termed natural regions, which reflect climatic variations as expressed by vegetation and soil patterns. The natural regions are divided into subregions, which are defined by regional landform features. Each subregion has several natural history themes that represent the diversity of features found within it.

The subregions are distinguished on the basis of the range and scale of natural features that occur within each natural region. For example, Grassland subregions are split primarily on the basis of climatic, soils and vegetation factors, Boreal Forest subregions are separated by vegetation, geology and landform features, and Rocky Mountain subregions are distinguished by differences associated with changes in elevation.

The following summary outlines the characteristics of each of the regions and subregions that occur in Alberta. Only the highlights and typical features of each subregion are discussed.

The Grassland Natural Region is a flat to gently rolling plain with a few major hill systems. Most of the bedrock is covered with glacial till deposits, although some areas are blanketed by glacial lake sediments, sand dune fields and outwash plains. Badlands have developed where river valleys and their associated coulees and ravines are carved deeply into bedrock. The Milk River drains the southeastern extreme of this natural region; the normally slow-flowing Red Deer, Bow, Oldman and South Saskatchewan rivers drain the remainder. Few natural lakes occur, and most water bodies are offstream reservoirs for storing irrigation water. Marsh wetlands develop in depressed areas where moisture is adequate.

Climatic conditions are typical of prairie landscapes, and provide this natural region with warmer and drier summers and milder winters than any other natural region in Alberta. Blue grama/ needlegrass or fescue grasslands and Chernozemic soils are characteristic of the region. Many animal species, especially those in the extreme southeast part of Alberta such as the short-horned lizard, occur nowhere else in the province. Other species include western meadowlark, burrowing owl, Richardson's ground squirrel, ground squirrel, and badger. Four subregions - Dry Mixedgrass, Mixedgrass, Northern Fescue and Foothills Fescue -are included in the Grassland Natural Region.

The Parkland Natural Region, with the exception of the Peace River Parkland Subregion, forms a broad transition between the grasslands to the south and the forests to the north and, in North America, exists only in the prairie provinces of Canada. Landforms consist of hummocky till and/ or gently rolling plains with a few deeply incised river valleys in northern Alberta, to rolling morainal terrain in south-central and western Alberta. Lakes are common, and major lakes include Beaverhill, Buffalo and Pine Lakes. There are numerous wetlands, many of which are slightly to strongly saline. The Red Deer, Battle and North Saskatchewan rivers flow through this natural region.

The regional climate is influenced by prairie, boreal and mountain landscapes and weather patterns. A mixture of aspen grovelands, shrublands and grasslands characterize the regional vegetation, and Chernozemic and Luvisolic soils typify the regional soils. Animals include species from the grasslands to the south (e.g., upland sandpiper, Baird's sparrow, Sprague's pipit) and the forests to the north (e.g., woodchuck, broad-winged hawk, rose-breasted grosbeak). There are three subregions in this natural region, which are separated on the basis of geographic location and vegetation differences--Central Parkland Subregion, Foothills Parkland Subregion and Peace River Parkland Subregion.

The Foothills Natural Region extends north from about Turner Valley, along the eastern edge of the Rocky Mountains in a gradually widening belt. It also includes several outlying hill masses such as Swan Hills, Pelican Mountains and Clear Hills. The rolling landscape is strongly influenced by bedrock features. Lakes tend to be small; the larger lakes include Buck Lake, Crimson Lake, Moonshine Lake and Musreau Lake. Wetlands, predominantly fens, are common in low-lying areas. This natural region is drained primarily by the Smoky, Athabasca, Pembina and North Saskatchewan Rivers.

Climate is influenced by both boreal and mountain landscapes and weather patterns. Mixed forests of

white spruce, black spruce, lodgepole pine, balsam fir, aspen, paper birch and balsam poplar are typical as are Luvisolic and Brunisolic soils. Wildlife species include boreal chickadee, black-capped chickadee, purple finch, ruby-crowned kinglet, ruffed grouse, spruce grouse, red squirrel, elk, black bear, grizzly bear and moose. There are two subregions within the Foothills Natural Region, the Lower Foothills Subregion and the Upper Foothills Subregion.

The Rocky Mountain Natural Region contains the most rugged, mountainous terrain in the province, and ranges from about 10 km wide in the Waterton Lakes National Park area to more than 100 km wide in the central portion. The three subregions of this natural region are the Montane Subregion, the Sub-alpine Subregion, and the Alpine Subregion. All are strongly influenced by mountain landscapes and weather patterns, and indicate changes in environmental conditions associated with differences in altitude. Lakes are generally small and scattered; Beauvais and Crowsnest Lakes and the Ghost Reservoir are typical of Montane lakes, and the Kananaskis Lakes and Spray Lakes Reservoir are typical of Sub-alpine lakes. Major rivers include the Crowsnest, Bow, North Saskatchewan, Athabasca and Smoky Rivers, and numerous fast-flowing glacial meltwater streams contribute to these rivers particularly in spring. Wetlands are scattered and confined to depressions and valley bottoms.

Elevation and topography, and associated climatic changes, create complex vegetation and soil patterns. Alpine vegetation at high elevations includes alpine sedge, dwarf shrub-heath, grouseberry, snow willow and moss campion communities on poorly developed soils or rock. At middle elevations, forests of lodgepole pine and Engelmann spruce dominate, with patches of spruce, fir, pine and larch near the treeline, and scattered grasslands, all on Brunisolic soils. Open Douglas fir, limber pine, lodgepole pine, white spruce and aspen forests interspersed with grasslands on Brunisolic soils are characteristic of lower elevations. Animal distributions show a similar trend, with hoary marmot, grizzly bear, mountain goat and bighorn sheep primarily at higher elevations in the sub-alpine and alpine subregions. Blue grouse, mountain chickadee, mule deer, elk, Columbian ground squirrel, marten, snowshoe hare, mountain caribou and black bear inhabit lower elevation areas.

The Boreal Forest Natural Region consists of broad lowland plains with many wetlands and discontinuous hill systems. The region has numerous lakes of varying size, the largest being Lac la Biche, Lesser Slave, Utikuma, Wabamun, Cold and Athabasca Lakes. The Peace, Athabasca and North Saskatchewan rivers are broad, generally slow-flowing rivers with only a few rapids, and drain much of the region. Wetlands are extensive and highly variable, with treed bogs and a variety of mineral-rich sedge fens as the major types. The huge wetlands of the Peace-Athabasca delta are important wildlife habitat. Many of the higher-elevation wetlands are underlain by permafrost.

Climatic conditions reflect a strong boreal influence. Typically, the winters are long and cold, the summers are short and cool, and the majority of precipitation falls between May and August. The regional vegetation is typically aspen-dominated, with mixedwood or coniferous forests at higher elevations or in wetlands. Soils are mainly Luvisolic on well-drained uplands and Organic in poorly drained lowlands. The Boreal Forest Natural region is home to a wide variety of wildlife species, including birds such as the flycatcher, northern water thrush, pileated woodpecker, goshawk, great grey owl, grey jay, spruce grouse, and sandhill crane, and mammals such as red squirrel, beaver, moose, wolf, black bear, lynx and river otter. The Boreal Forest Natural Region is a highly diverse landscape and includes six subregions. These are the Dry Mixedwood Subregion, Central Mixedwood Subregion, Wetland Mixedwood Subregion, Boreal Highlands Subregion, Peace River Lowlands Subregion, and the Sub-Arctic Subregion.

The Canadian Shield Natural Region occupies the far northeast corner of Alberta. The Canadian Shield geological formation and large expanses of bedrock-derived sand have produced two distinctive subregions, the Athabasca Plain Subregion and the Kazan Upland Subregion. There are many lakes, particularly in the Kazan Upland Subregion, the largest of which is Lake Athabasca. The Athabasca River is the only major drainage, and defines the western border of the natural region. Wetlands are less extensive than in the adjacent Boreal Forest Natural Region, and are mainly sedge fens or treed bogs dominated by black spruce.

Climatically, these subregions have relatively warm and dry summers and cold winters compared to many of the Boreal Forest subregions. Dry jack pine and wet, poorly drained black spruce forests on Brunisolic and Organic soils, respectively, are typical of the region. Little is known about wildlife populations, but they are probably similar to those of the adjacent Peace River Lowlands and Central Mixedwood subregions of the Boreal Forest Natural Region. Nighthawk, gray jay, raven, common loon, spotted sandpiper, alder flycatcher, hare, lynx, moose, beaver and black bear are a few of the species that are known to occur.

RIVER FLOWS BY NATURAL REGION

Table A1.1 shows maximum, minimum and mean annual flow for selected sites in the six natural regions of Alberta. The Grassland Natural Region shows the greatest variability in flow, while the Rocky Mountain, Foothills and Canadian Shield Natural Regions have the most stable annual flows.

The Rocky Mountain Natural Region has the highest level of mean annual runoff, followed by the Foothills and Canadian Shield Natural Regions. The Grassland Natural Region has the lowest level of mean annual runoff, with less than 10 mm.

Table A1.2 shows the monthly flow distribution for streams in the Natural Regions of Alberta. In the Grassland, Parkland and Boreal Forest Natural Regions, over 40 percent of the mean annual flow occurs in one month. This is a result of spring snowmelt. The month of highest runoff ranges from March in the southern grasslands to May in the northwestern boreal forest.

In the Grassland Natural Region, there is a significant decline in flow after May, with many streams often having zero flow from June onwards. The Canadian Shield Natural Region has extensive lakes that act as storage areas for water. This Natural Region has the lowest amount of variability in monthly flow.

Table A1.1 Flow Distribution for Streams in Alberta's Ecoregions.

Ecoregion	Stream Course	Monthly Flow as % of Annual Runoff											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Boreal Forest	Waskatenau Creek near Waskatenau	n/a	n/a	2.40	63.70	13.70	4.10	7.40	2.90	3.40	2.4	-	-
	Lutose Creek near Steen River	n/a	n/a	0.00	8.00	42.10	24.10	12.70	5.20	3.90	4.00	-	-
Rocky Mountain	Castle River near Beaver Mines	1.50	1.50	1.70	7.40	30.30	32.00	10.60	3.60	2.90	3.40	3.00	2.10
	Elbow River above Elbow Falls	3.20	3.00	2.80	3.10	13.50	26.10	15.20	10.20	8.00	6.20	4.80	3.90
Foothills	Wolf Creek near Highway 16	-	1.00	1.50	11.70	18.70	18.50	19.60	9.90	8.00	5.70	2.70	1.60
	Prairie Creek near Rocky Mountain House	3.1	3.00	3.50	7.30	12.80	17.20	15.40	11.10	10.20	7.70	5.00	3.7
Parkland	Rosebud R. below Carstairs Creek	-	n/a	27.20	46.70	9.90	7.90	4.70	0.90	1.40	1.30	-	-
	Buffalo Creek at Highway 41	-	n/a	9.40	49.80	13.70	10.70	7.50	3.00	2.70	3.20	-	-
Grassland	Alkali Creek near the Mouth	-	n/a	11.00	86.80	1.60	0.40	0.20	0.00	0.00	0.00	-	-
	West Arrowwood near Arrowwood	n/a	2.70	41.20	43.30	5.90	2.50	3.10	0.40	0.30	0.60	-	-
Canadian Shield	Marten River above Thoa River (NWT)	3.60	2.60	2.10	3.30	20.40	13.40	11.20	9.90	10.50	9.70	7.80	5.50
	Douglas River near Cluff Lake (Saskatchewan)	6.00	5.70	5.50	8.00	15.40	9.70	9.20	8.40	9.20	9.20	7.20	6.40

Source: Water Resources Services, Alberta Environmental Protection.

Table A1.2 Streamflow Summary for Indicative Streams in Alberta's Ecoregions.

Ecoregion	Stream Course	Drainage Area (km^2)	Annual Runoff Volume				Mean Annual Runoff (mm)
			Max (dam^3)	Mean (dam^3)	Min (dam^3)	Ratio Max/Min	
Boreal Forest	Waskatenau Creek near Waskatenau	312	34 900	8 760	398	87	28
	Lutose Creek near Steen River	292	37 900	15 800	1 040	36	54
Rocky Mountain	Castle River near Beaver Mines	823	857 000	503 000	174 000	4.9	611
	Elbow River above Elbow Falls	437	215 000	148 000	88 900	2.4	339
Foothills	Wolf Creek near Highway 16	829	297 000	129 000	41 300	7.2	156
	Prairie Creek near Rocky Mountain House	859	259 000	135 000	72 700	3.6	157
Parkland	Rosebud River below Carstaris Creek	753	37 900	9 210	517	73	12
	Buffalo Creek at Highway 41	714	22 000	5 480	1 990	11	7.6
Grassland	Alkali Arrowwood near Arrowwood	590	15 000	1 770	21	>100	3 0
	West Arrowwood near Arrowwood	775	33 600	7 590	136	>100	9.8
Canadian Shield	Marten River above Thoa River (NWT)	738	236 000	16 000	84 300	2.8	217
	Douglas River near Cluff Lake (Saskatchewan)	1 690	764 000	600 000	350 000	2.2	355

Source: Water Resources Services, Alberta Environmental Protection.

APPENDIX 2 - STATUS AND BACKGROUND OF SPECIES AT SERIOUS RISK.

AMPHIBIANS

Species	Current Status	Background
Great Plains Toad	Rare prairie resident. Total population unknown but apparently declining.	Critical prairie breeding habitat declining because of drought, drainage and cultivation of wetlands. Clean water, apparently required for breeding, is compromised by intensive livestock use of breeding area ponds.
Long-toed Salamander	Rare resident, limited number of patchy disjunct populations.	Isolated populations focused in mountain pass areas particularly vulnerable to potential habitat destruction/alternation associated with industrial, recreational, transportation development. Additional data required.
Northern Leopard Frog	Decreasing.	This previously common and widespread species has disappeared from the vast majority of its Alberta range, with only six known successful breeding areas located in 1990. Similar but less complete range and population declines documented throughout Canada. Protection of remnant breeding areas is essential while investigations of the biological needs of this species continue.

REPTILES

Species	Current Status	Background
Short-horned Lizard	Rare and localized.	Population status and trend unknown, but occurs in strongly localized and isolated sandy grassland/badland/river break habitats.
Western Hognose Snake	Extremely rare (only 36 site or specimen records available).	Information on populations and hibernacula locations is essential to properly determine status and management requirements.

Note: Red-listed species are those that are or will be considered for endangered species designation.

BIRDS

Species	Current Status	Background
Baird's Sparrow	Population information poor but preliminary estimate of 9 000 singing males in 1989.	Concern over apparent population decline throughout Canadian range, possibly as a result of alteration of key prairie habitats. Clarification of population status and trend is essential. National status threatened.
Burrowing Owl	Endangered animal estimated to have 700 to 900 breeding pairs.	Population declining in key prairie habitats across Canada. Threats include cultivation of nest sites, loss of ground squirrels and pesticide use.
Ferruginous Hawk	Endangered animal estimated to have 1400 to 1700 pairs.	If current recovery of breeding population continues and key nesting and feeding habitats can be secured, this species can be considered for change to Blue List.
Loggerhead Shrike	Population low, poorly understood, and probably declining. Estimated to have fewer than 500 pairs.	Concern over known population decline in much of Canada. Conservation of prairie shrub nest habitat and improved information on population status and trend is necessary to properly manage this species. National status threatened.
Long-billed Curlew	Population low, possibly declining.	This species relies on native prairie grassland and is thought to be declining throughout its Canadian range. Alberta data are presently insufficient to allow effective management.
Mountain Plover	Endangered animal (four to six breeding pairs known).	At extreme northern limit of breeding range in Alberta. Requires native grassland management to provide preferred open nest sites.
Peregrine Falcon	Endangered animal (10 breeding pairs).	With continued intervention, existing pairs in northern Alberta and in Edmonton and Calgary are relatively secure. Provincial recovery will depend on declining pesticide levels in prey and releases of captive-reared chicks into southern Alberta.
Piping Plover	Endangered animal (estimated to be 100 to 150 breeding pairs).	Threatened or Endangered throughout North America. Recovery requires protection from human disturbance and management of key shoreline nesting habitats.
Trumpeter Swan	Endangered animal. Breeding population has increased from 36 pairs in 1980 to 65 pairs in 1990.	Critical shortage of key winter habitat in the Tri-State area (Idaho, Montana, Wyoming) still limiting population growth. Existing breeding habitat relatively secure.
Upland Sandpiper	Unclear.	Populations have probably declined with loss of native prairie grassland nesting areas, but adequate population figures are not available.
Whooping Crane	Endangered animal (wild population less than 150 individuals).	All nest sites protected in Wood Buffalo National Park. Conservation of both migratory habitats and potential breeding habitats in Alberta is required.

MAMMALS

Species	Current Status	Background
Swift Fox	Endangered animal, approximately ten breeding pairs in 1990 from experimental releases.	Feasibility of a major reintroduction program being examined by a national recovery team. Ability of this species to maintain itself in prairie Canada still in doubt.
Wood Bison	Endangered animal, entire Alberta population in captivity (approximately 350 mainly in Elk Island National Park).	Restoration of this species in Alberta depends on resolution of disease concerns in northern Canada.
Woodland Caribou	Endangered animal, population stable to declining (approximately 3500 individuals).	Concern over maintenance of old-growth forest to provide critical winter habitat. Management of predation in some populations, improved population monitoring and habitat protection are being addressed.
Yellow-cheeked Vole	Extremely rare, possibly extirpated.	No records since early 1900s (in the Athabasca River area of the Boreal Forest), but little inventory data available from potentially suitable habitats.

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READER EVALUATION

Help us evaluate Alberta's first State of the Environment Report. Please answer the questions below and return your response to:

Alberta State of the Environment Report
c/o Alberta Environmental Protection
Research and Strategic Services
9th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

1. Was the information in this report presented in a clear and understandable way? If not, what suggestions would you have for changes?

2. Was there enough information presented in each of the major sections? If not, what additional information would you find useful?

3. What subject areas would you like to see covered in future reports?

4. Are there any other comments you wish to make on this report?

Thank you for taking the time to respond to the above questions. Your responses will help us produce future reports that meet the your needs and expectations⊛